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WALTER MULFORD, CONSULTING EDITOR

WILDLIFE MANAGEMENT

Upland Game and General Principles

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WILDLIFE MANAGEMENT

Upland Game and General Principles

Volume I

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WILDLIFE MANAGEMENT

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PREFACE

The field of wildlife management has many sides and many angles. Fundamentally it is the process of making land and water produce sustained crops of wild animals. The goal is clear and definite, but the roads toward that goal are several and follow numerous byways. In the first place many different classes of animals are involved—migratory species, fur bearers, game species, nongame species. Management includes the manipulation of widely varying environments. It is concerned with many occupations, including agriculture, forestry, and range management, and may involve encouragement or restraint of both animal populations and human activities.

Interest in wild animals is deeply rooted in the minds and emotions of a broad cross section of humanity. This interest manifests itself in such widely different individuals as the hunter who enjoys the sport of shooting and the ardent conservationist who desires only to protect innocent creatures. Between these two extremes are many intermediate degrees of interest.

Fundamentally, wildlife management has a sound economic basis. Crops of wildlife can be grown on land not suited to other crops. There are millions of acres in North America in this class of land. Wildlife can also be produced on land used for agricultural crops, but as yet adequate means for paying the landowner for his efforts have not been found.

The past decade has produced intensive activity on the part of educational institutions, research organizations, and public agencies, both state and Federal, in obtaining information as a basis for managing wildlife. A wealth of data has been collected, and genuine progress is being made toward better methods of management. It appears, therefore, that this is an appropriate time to summarize these findings and to determine the extent of the progress so far made. Such a stocktaking not only will collect and collate the information now available but should point the way for investigative work in the future. This book is an attempt at such a summary and evaluation.

In presenting the material that follows, the author has tried to emphasize the quantitative approach. It is fully realized that in many cases the data presented are not wholly satisfactory, and future findings may provide figures superior to many of those given; but if these values are the only data available at the moment, they at least provide starting points

from which future corrections can be made. If the material here presented serves as a datum point, its inclusion will have been fully justified.

Much published material in the various phases of wildlife management is available. The author has necessarily drawn heavily upon the published work and experiences of others, and in the availability of this material he is most fortunate. Any errors of omission, oversight, or interpretation are the author's alone, and for them he takes complete responsibility.

Conclusions as to the success or failure of the wildlife management concept rest with those who have the interest and energy to carry the work forward. Millions more hunters and fishermen are appearing each year. More leisure time, faster transportation, and new gadgets are making increased demands on the available supply of game. Furnishing new and greater supplies of wild animals is a challenge to the courage and resourcefulness of administrators, research workers, and land managers. It is the hope of the author that this book may be of some help in attaining that end.

"Wildlife Management" was written originally as one volume, containing sections on upland game, general principles of wildlife management, fur bearers, waterfowl, and game fishes. Because of the difficulty of publishing and marketing so large a volume, the material has been divided into two parts, the first of which is Upland Game and General Principles of Wildlife Management.

REUBEN EDWIN TRIPPENSEE

AMHERST, MASS.
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R. E. T.

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CHAPTER I

THE FARM AS A WILDLIFE HABITAT

Approximately 52 per cent of the total land area of the continental United States, or slightly less than 1 billion acres, is contained in farms, of which 42 per cent is classed as cropland, 38 per cent as pasture, 15 per cent as woodland, and 5 per cent as miscellaneous. Large numbers of wild animals live upon these lands, constituting a great part of the game and fur bearers that support the so-called "American system" of free hunting and trapping.

Before man changed the land by removing the trees, much of the area now in farms produced trees and shrubs and a rich fauna of game animals, fur bearers, and songbirds. These rich lands, however, were an inducement to the early settler to move westward, first for the fur they produced, and later because of the lands' capacity to grow domesticated plants and animals. Most of the productive farm lands have now been exploited, together with some that can scarcely support agricultural activities. Other millions of acres with a rainfall too low for satisfactory agriculture are now used for the grazing of livestock. These lands formerly supported uncounted numbers of wild animals. At present slightly more than one-fifth of the total land area of the United States is used to produce farm crops, another fifth is used for grazing and range purposes, and the remainder is occupied by forests, urban centers, and other nonagricultural lands (13).

History tells us that at one time the pioneer was able to stand in his cabin door and shoot a turkey for his dinner. Waterfowl swam in great numbers on every pond and river. Fish were plentiful in every stream and lake. Deer, bear, and the smaller fur bearers furnished the settler with meat, clothing, and articles of trade. As the clearings enlarged and the forest disappeared, new forms of wildlife came in. The bobwhite and rabbit, which were formerly confined to the marshy seashore and open glades in the forest, benefited by the change in environment from forest to open conditions and increased in numbers as the garden spots and turnip fields of the settler appeared. Conditions were ideal for many of the small birds and mammals. The remnants of woodlands furnished escape and

nest sites; the brushlands grew sprout and herbaceous material in which the rabbit and bobwhite lived; and the grain and vegetables grown by the farmer gave the extra food so essential to open-land wildlife. During the nineteenth century the ring-necked pheasant and the Hungarian partridge were imported from Europe and Asia and gradually enriched the farm-game fauna of the agricultural region of the North American continent.

With domesticated crops came insects to prey on them and to plague the farmer. Other insects, such as the mosquito, were a nuisance to the tiller of the soil and his family. The potato beetle appeared to defoliate the potato vines. The Hessian fly attacked his wheat. A host of other insects annoyed him at every turn. He had, however, another host to help protect him from the insect hordes. These were the birds and small mammals whose environment he had helped to make attractive. The bobwhite brought off a brood of young which were led up and down the rows of potato vines, consuming the potato beetles. Bats, chimney swifts, and night hawks cleared the air of insects by night, and robins, wrens, bluebirds, and flycatchers worked on both flying and crawling insects by day. Other birds helped to consume and destroy the seeds of weeds that were competing with the farmer's crops (2). The bobwhite alone consumes large quantities of both insects and seeds. Forbush (*40 g.r.*) [1] says this bird eats 141 species of insects and may consume as many as 5,000 chrysanthemum black flies in a single day. It also feeds on at least 129 different species of weeds and has been known to consume 10,000 seeds of lamb's quarter or 30,000 of rabbit-foot clover in a day's feeding. It has been estimated that half the food of 1,400 different species and varieties of North American birds consists of insects (1).

The value of fur produced on American farms runs to stupendous figures. The farmers and trappers of the United States receive a yearly return of 78 million dollars for raw furs, and the annual retail turnover for the finished product in 1929 was half a billion dollars (*51 g.r.*). A high return from raw muskrat furs, now the most abundant of our fur bearers, is received by the youth living on the farm. Swamps, marshes, stream and lake borders are of little value for commercial farming but produce an abundant crop of valuable fur bearers and other wild animals. This supplemental farm income costs the farmer practically nothing and goes on year after year with little effort on his part.

Making a living from the land involves long hours of hard and tedious work. To the farmer and his family part of the reward for this labor comes from the joy of living close to nature and from the spiritual help they receive through their plant and animal neighbors. Who has not been lifted up in his daily struggle by the cheery whistle of the bobwhite or the song

[1] "*g.r.*" refers to the General References at the end of the book.

of the bobolink? Man is a creature of nature and has been molded both physically and mentally by millions of years of contact with it. Man's associations with wild animals, both pleasant and unpleasant, have, no doubt, left an impression that we can no more control than we can change the color of our skin or the quality of our cell structure. Domestic stock were once wild animals and were tamed and put to use by our recent ancestors. This accomplishment has brought the human race many advantages. All of our surroundings remind us of the important part nature has played in giving us sustenance, comfort, and enjoyment. Thus our interest in the trees, flowers, birds, and beasts in their wild condition and the urge to maintain and encourage the production of natural things around us are based on a historical background that has made it possible for us to progress in culture and science to our present level (14).

Wildlife Inhabitants of the Farm. The principle that "gold is where you find it" does not apply to wild animals. Each species requires a specific type of habitat, which, if lacking, precludes the existence of the species, although some animals are more tolerant in their requirements than others. Moreover, lands submarginal for agricultural and forest production are frequently not productive for wildlife. Thus, pheasants reach a high point of abundance in the fertile farm lands of Wood County, Ohio, but are much less abundant in the river-bottom lands of New Hampshire.

Numerous game animals, fur bearers, fish, and songbirds are found in the various habitats of the American farm. Not all of these can be given, as the list contains several hundred species. The seven more important game species commonly found on farms in the Eastern and Central parts of the United States are the ring-necked pheasant, bobwhite quail, Hungarian partridge, cottontail rabbit, gray squirrel, fox squirrel, and woodchuck. All these animals prefer a variety of cover, moving back and forth across the edges of two or more vegetative types in search of food or shelter. Some, like the squirrels, have permanent homes in the trees of farm wood lots and make forays out into grain- or cornfields for food. Others, like the cottontail, move to the hayfields for the early summer months and back to the brushlands or woodlands during the fall and winter (12).

Tillage Lands. Tillage lands include all the lands used for cultivated crops. Hay, grains, root crops, and gardens are all contained in this classification. Hay, which includes both wild and tame varieties, is a favorite crop for all farm-game species except the squirrels. Food and cover are plentiful in the hayfields and develop early in the season. Hayfields also furnish roosting and nesting areas for birds and provide nearly all the needs of rabbits and woodchucks. From the standpoint of area, hay occupies in general more acreage than any other tillage crop, and as a wildlife habitat it is used more frequently in the aggregate, although other less abundant types may be preferred.

Another attractive habitat is the grainfield, which is frequented by all farm game. Both fall- and spring-sown grains supply food of high quality. The former is particularly desirable as succulent food during the fall and winter. As cover the fall-sown grains are about equal to hay, but spring-sown grains develop more slowly. Both hay and the small grains remain relatively undisturbed until the period of harvest, but the land occupied by cultivated crops is worked over constantly, to the detriment of this type as a wildlife habitat. Corn occupies an intermediate position, forming excellent cover following the period of cultivation. Stalks left standing during the winter furnish protection for animals that come in to feed on waste grain.

Root crops and gardens supply insects for bobwhite and succulent food for rabbits and woodchucks. Beans, corn, discarded tops of sugar beets, and other residues left on the ground and in the gardens at harvesttime furnish natural food patches for fall and winter use.

Pasture. Land that is heavily pastured ordinarily furnishes neither good food nor cover. On such lands the grass is too short to offer protection, and the closely cropped plants produce but few seeds suitable for food. Where woody species like wild plum, Osage orange, hawthorn, and prickly ash come in, the lack of cover is partially overcome, but the pastured field is never ideal from the standpoint of a complete seasonal habitat. Borders of pastures may supply high-grade greens in the form of white clover and dandelions, however, and also make excellent sites for woodchuck burrows.

Woodlands. Woodlands, particularly those which contain mature trees, are the year-round haunts of fox and gray squirrel and furnish an attractive and stable type of cover for other farm-game species. Food in the form of bark and buds is ever-present for rabbits, and the wealth of shrubs that grow along the woodland border provides food and cover for pheasants and bobwhite. For animals that feed primarily in open fields, near-by woodland helps to break the wind and offers escape cover.

As permanent cover, the woodland is superior to most other types of vegetation, for aside from the shedding of deciduous leaves it undergoes few radical changes during the season. Cropland may prove suitable at one season, only to become barren and unattractive at others, but the woodland, summer or winter, provides food and cover in one form or another (15).

Wasteland. Wastelands, such as the margins of ponds and streams, marshes, swamps, seepage areas, fence rows, gullies, and old machinery dumps, are particularly well suited to rabbits, pheasants, and bobwhite quail. All are relatively permanent (6). Marshes and the damp margins of ponds and streams support a luxuriant growth of vegetation suitable both as food and cover. Such locations are cooler in summer and better protected from winter winds than the higher ground. Gullies, fence rows,

and other waste places make suitable nesting sites for cottontails, pheasants, and quail, and along these natural lanes game can travel from one location to another in comparative safety.

RECOMMENDATIONS FOR IMPROVING CONDITIONS FOR WILDLIFE

Measures to Improve Cover. The fundamental concept that cover in one or more forms is an essential part of any wildlife habitat is discussed in detail elsewhere. The recommendations that follow are suggestions for developing cover on farms where this element of the habitat is unsatisfactory.

New Plantings. Plantations offer perhaps the best means of creating extensive areas of woodland cover and possess the added advantage of producing wood crops that eventually should produce revenue of their own. Planting of this character can be made by farm labor at comparatively little cost once the planting stock has been purchased. Both conifers and deciduous species have their own particular advantages, but mixed plantations are better than pure stands of either, furnishing a greater variety of cover and food at all seasons (4).

Suitable planting sites are rarely lacking. These may take the form of eroding hillsides, abandoned pastures, and wasteland not suited to agricultural use because of terrain or unfavorable soil conditions. Eastward such areas are likely to be all too common, and many tracts now in cultivation or pasture might better be converted to forests (7). Westward, especially in the prairie and plains states, suitable land may be less common, and climatic conditions may not favor the successful development of plantations. On these locations plantings take the form of windbreaks, and forest plantations are restricted to sheltered sites where moisture conditions are better than average.

Windbreaks, planted to counteract high wind velocities, to prevent loss of soil and evaporation of moisture from fields, and to act as snow fences, offer another means of creating cover. In regions where windbreaks are most frequently planted, they are doubly important from the viewpoint of wildlife, because natural woody vegetation is scarce or lacking. Conifers make the best windbreak, but deciduous species are occasionally used for this purpose.

In Germany farmers frequently develop a winter cover of trees toward which the game is forced during farming operations of the centripetal type, or *toward the center*. This "remise," so-called, is made of carefully grouped trees arranged near the center of the estate. During the winter it holds game when the cover of farm crops is not available and acts as escape cover during the summer. In Germany, as in America, the farmer is interested not only in producing game but also in holding it on *his own land* (16).

Planting stock may be procured from private or state nurseries, the

latter frequently furnishing materials at cost. Wild stock makes a suitable substitute if available. The following species are recommended for use in the Lake states and the Northeast: white pine, Norway (red) pine, Scotch pine, red spruce, white spruce, Norway spruce, hemlock, northern white cedar, ground hemlock (Canada yew), the native oaks, sugar maple, basswood, and white ash. Cedar is suitable for use in moist situations, but the others should be planted on upland soils. All except the low-growing ground hemlock are arborescent (19).

Advice on planting methods and the selection of stock can be found in various government publications [1] or obtained direct from representatives of the Extension Service.

Development of Wood Lots and Wastelands. The problem of improving cover in the *wood lot* is frequently not an important one because cover is usually present here in some form. Only in heavily grazed woodland is cover likely to be entirely unsatisfactory. Improvement measures in overgrazed wood lots may be urgently needed unless abundant cover of a suitable nature is available elsewhere.

Two procedures may be adopted: underplanting and control of grazing. *Underplanting* establishes cover artificially; *control of grazing* excludes livestock from the woodland area, thereby permitting native vegetation to develop by natural means. The first method has certain advantages because it obtains results more quickly and establishes cover of any desired composition, shape, and size in the exact spot where it is most needed. On the other hand, planting requires some monetary outlay, and this type of plantation, unlike those established on open land, produces little or no revenue in its own right.

Conifers are most suitable for underplanting, mainly because they furnish a superior type of cover. In stands of pure hardwoods the lack of evergreen vegetation for winter use can be an important limiting factor, and in pastured woodlands the conifers are more nearly immune to grazing than the hardwoods. Only those species reasonably tolerant to shade are suited to understory planting, for the less tolerant species either succumb or develop too slowly. Of the eastern conifers, hemlock and the spruces meet his requirement. Northern white cedar may be substituted on moist soils of high fertility. Ground hemlock (Canada yew) is excellent for low-sprawling cover and withstands dense shade. The less tolerant white and red pines are ill adapted to any but open woodlands where the overhead canopy is comparatively thin.

A second method for improving woodland cover is to exclude grazing animals. This procedure not only benefits wildlife by restoring an under-

[1] Growing and planting coniferous trees on the farm. *U.S. Dept. Agr. Farmers' Bul.* 1453.

The windbreak as a farm asset. *U.S. Dept. Agr. Farmers' Bul.* 1405.

story of woody and herbaceous plants but benefits the woodland considerably from the standpoint of producing timber crops. The grazing of wood lots is recommended by neither foresters nor game technicians (32).

The improvement of wasteland has been discussed in part in the preceding section. Such areas, however, can serve a useful purpose as cover even though new planting is not undertaken. In regions where natural vegetation develops rapidly, such areas soon produce a dense cover of native species, which serves both as shelter and feeding ground. The composition of woody vegetation that is produced naturally is likely to be largely deciduous in character, and conifers, if desired, must be introduced artificially.

Artificial cover can be developed from waste materials found on almost any farm. Brush, logs, stones, and various discarded materials, if properly handled, make excellent temporary refuge and escape cover for all farm game. Escape cover of this character should be present at well-distributed points over the farm when suitable natural cover is not present. One unit ought to be no farther than 400 to 600 feet from the next. A good retreat is one that admits a bird or small mammal but excludes larger animals like dogs and foxes. Two or more logs placed on field stones, brush piled over a log, or a roll of discarded wire fencing provide excellent escape cover. Brush thrown into a gully or ravine serves both as a check to further erosion and as concealment for small animals. Stone walls supply numerous retreats for rabbits and squirrels, and rock piles can be so made that openings are present for the use of small game. Automobile bodies, abandoned farm machinery, waste sheet iron, and tangled wire all provide material over which vines and shrubbery grow or brush can be piled (5, 20).

Maintenance of Specific Cover Types. The farm manager who is attempting to create desirable conditions for wildlife should understand that the processes of nature are not static but are ever-changing. A windbreak or plantation that is highly desirable for cover in 1940 will change by 1990 to stately mature trees with little or no foliage near the ground. Thus, the process of creating low dense cover depends on the intermittent establishment of new plantings every 10 to 20 years. Open land becomes woodland unless pastured or treated in some way to hold back the woody growth. Herbaceous marshes gradually become shrubby swamps. In other words, cover is changing constantly, and the farm manager must be fully cognizant of this process and adopt measures to counteract it if he is to maintain satisfactory cover year after year for specific animals (29).

Propagation of Fruit-bearing Perennials. Johnny Appleseed was the original wildlife manager, but his product lacked variety. Sportsmen and wildlife managers have since improved upon his technique by recommending perennial plantings along fence rows, in kettle holes, and in other waste places. Plantings of this character produce a nearly perpetual food supply and require little attention once the plants are well established.

TABLE 1. A LIST OF PERENNIAL COVER AND FOOD PLANTS SUITABLE FOR FARM GAME

Plants	Cover		Food		
	Summer	Winter	Summer	Fall	Winter
Vines:					
Bittersweet	x	x	—	—	x
Blackberry	x	x	x	x	—
Grape	x	x	—	x	x
Matrimony vine (Chinese)	x	x	—	—	—
Raspberry	x	x	x	x	—
Rose	x	x	—	—	x
Shrubs:					
Japanese barberry	x	x	x	x	x
Black alder	x	—	—	x	x
High-bush cranberry	x	—	—	x	x
Chokeberry	x	—	—	x	x
Coralberry	x	x	—	x	x
Dogwoods	x	x	—	x	x
Black elderberry	x	—	x	x	x
Red elderberry	—	—	x	—	—
Wild rose	x	x	—	x	x
Japanese rose	x	x	—	x	x
Viburnums	x	x	—	x	x
Low-growing deciduous trees:					
Mountain ash	—	—	—	x	—
Flowering crabs	—	—	—	x	—
Flowering dogwood	—	—	—	x	x
Fruit trees:					
Apples	—	—	—	x	x
Cherries	—	—	x	—	—
Pears	—	—	—	x	—
Plums	—	—	—	x	—
Nut-bearing trees					
Butternut	—	—	—	x	x
Beech	—	—	—	x	—
European chestnut	—	—	—	x	x
Hickories	—	—	—	x	x
Oaks	—	—	—	x	x
Walnut	—	—	—	x	—
Evergreen trees:					
Red cedar	—	x	—	—	x
White cedar	—	x	—	—	x
Scotch pine	—	x	—	—	x
White pine	—	x	—	—	—
Norway pine	—	x	—	—	—
Norway spruce	—	x	—	—	—
White spruce	—	x	—	—	—
Red spruce	—	x	—	—	—

Planting stock for the most part will be of seedling origin, but some plants may be propagated by cuttings or layering. Propagation by cuttings is a method by which a short section of live wood (usually between 10 and 20 inches) is cut from the stem of the plant to be propagated and partially entrenched in moist soil, where it remains until the buried part develops a system of adventitious roots. Generally, the cut stems are set out as a group in suitable soil until the roots develop and then are transferred to the final planting site. Grape, bittersweet, Virginia creeper, honeysuckle, nightshade, wild rose, coralberry, and willow can be treated in this manner. Cuttings should be made in late winter or early spring before vegetative growth begins. Other plants can be manipulated similarly, but results are often uncertain, and many require a specialized technique that has no place in a volume of this character. For such plants, seedling stock is recommended.

Propagation by layering is a method in which a section of a branch or vine, still attached to the parent plant, is covered with soil. Once roots are established, the rooted part is cut from the parent and removed to a new location. Any of the berry varieties are adapted to this treatment.

Propagation of Food Patches. Even before the discovery of America, Kublai Khan was planting food patches in Mongolia to ensure an abundant game crop. Today this measure is becoming increasingly popular as sportsmen and farmers more fully appreciate the role of food in the proper management of game. By definition, a *food patch* is any plot of domestic food plants (usually small grains) reserved for the use of wild animals. It serves primarily as a source of food and to a lesser extent as cover. It may be an area specifically planted and set aside for the purpose or only a portion of the regularly grown grain crops left uncut at harvest (9).

Size, Shape, and Number. To be effective, the area of a food patch should not be less than ⅛ acre. Patches of more than ½ acre are probably larger than necessary. Several well-distributed patches aggregating an acre fulfill requirements more fully than a single patch of that size. The number, however, depends upon the degree to which natural food supplies are lacking and the size of the farm. One patch for each 40 acres is considered the minimum. Long narrow patches are best.

Location. Preferably, patches should be grown on good soil, but this procedure may not always be possible. If poorer soils are selected, larger areas must be reserved to produce a given amount of food. More important than soil, however, is the matter of accessibility. Only when patches are located near cover from which animals can enter without exposing themselves do they fulfill their function. Where contiguous cover or a suitable approach lane is lacking, food patches are less frequently used, except, perhaps, in the case of the Hungarian partridge and prairie chicken, which frequent open fields and grain stubble. The following locations are recommended:

Pheasant—near roosting cover in marshes and swamps
Bobwhite and cottontail rabbit—near good cover of shrubby or wooded character
Hungarian partridge and prairie chicken—in open fields (17)

Plant Materials and Propagation Methods. Domestic grains have been used for food patches more frequently than other plant materials. Plants like rape and clover are sometimes planted for their succulence, but the grains are considered superior in most respects. For fall, winter, and early spring use, corn and soybeans are excellent. Both are highly nutritive, hold their grains until spring, and possess unusual properties of snow resistance. Buckwheat supplies a palatable winter grain but tends to lodge by late fall or early winter unless ways are found to support it.

TABLE 2. CULTURAL AND NUTRITIVE CHARACTERISTICS OF PLANT MATERIALS SUITABLE FOR FOOD PATCHES

Plant	Method of sowing	Pounds of seed per acre	Seasonal food value *			
			Fall	Winter	Spring	Summer
Buckwheat:						
Common......	Broadcast	15–30	*S*	*S*	*S*	
Tartarian.....	Broadcast	50	*S*	*S*	*S*	
Corn:						
Kaffir.........	Drills — 2½ ft.	6	*S*	*S*		
Yellow field...	Drills — 3 ft.	7	*S*	*S*	*S*	
Sweet.........	Drills — 3 ft.	7	*S*	*S*	*S*	
Feterita.......	Drills — 3 ft.	6	*S*	*S*		
Hegari........	Drills — 3 ft.	4	*S*	*S*		
Millet:						
Common......	Broadcast	10–20	*S*			
German.......	Broadcast	10–20	*S*			
Hog..........	Broadcast	10–20	*S*			
Japanese......	Broadcast	10–20	*S*			
Pearl.........	Broadcast	10–20	*S*			
Milo:						
Dwarf yellow..	Drills — 3 ft.	5	*S*	*S*		
Wheatland....	Drills — 2½ ft.	5	*S*	*S*		
Peas:						
Canadian.....	Drills — 2 ft.	180	*S*		*G*	*G*
Rye:						
Winter........	Broadcast	85	*G*	*G*	*G*	*S*
Sorghum:						
Early amber...	Drills — 3 ft.	6	*S*	*S*		
Rox orange...	Drills — 3 ft.	6	*S*	*S*		
Soybeans......	Drills — 3 ft.	30–40	*S*	*S*	*G* + *S*	*G*
Sudan grass.....	Broadcast	20	*S*			*G*
Wheat:						
Winter........	Broadcast	90	*G*	*G*	*G*	*S*

* The symbol *S* stands for "seed," *G* for "greens."

Planted with the stiffer stemmed soybeans, it stands reasonably well. Winter wheat and rye are utilized during the winter as succulent food but mat down and become inaccessible in regions of heavy snowfall.

Other plants like the sunflower, millets, and sorghum provide food of high quality but are likely to be consumed before winter sets in, either by resident game birds or by flocks of smaller birds migrating southward. Spring-sown wheat, oats, and barley, which mature in late July or August, possess little value as materials for food patches except during midsummer.

Corn, soybeans, and other spring grains should be sown between May 1 and June 15; the fall grains—winter wheat and rye—between Sept. 15 and Oct. 15 (9).

Mixtures of grains are frequently planted in the same patch to care for several seasonal needs in a single operation. Two mixtures that have been developed for Michigan and Pennsylvania conditions are in common use. Both are made up by reliable seed companies and sell for 7 to 10 cents a pound.[1]

The Michigan Mixture (26)	Pounds
Sudan grass	14.0
Buckwheat	12.6
Hungarian millet	9.0
Manchu soybean	8.4
Canadian field peas	8.4
Flax	8.4
Hemp	8.4
Golden glow corn	7.7
Early amber sorghum	7.4
German millet	4.5
Hog millet (proso)	4.2
Hegari	4.2
Mammoth Russian sunflower	2.8
Total	100.0

The Pennsylvania Mixture — 1939	Pounds
Dwarf Japanese broomcorn	18
Early amber sorghum	18
Sudan grass	12
Japanese buckwheat	8
Sunflower	8
German millet	7
Japanese millet	7
Hog millet	7
Kaffir corn	6
Wheatland milo	4
Flax	3
Dwarf Essex rape	2
Total	100

[1] The Michigan mixture is sold by the Michigan Farm Bureau, Lansing. For information on the sale of the Pennsylvania mixture write the Pennsylvania Game Commission, Harrisburg.

These mixtures should be sown broadcast (15 to 20 pounds per acre) in the spring. On soils of low fertility 300 pounds of balanced commercial fertilizer per acre are recommended.

The success of food patches and the volume of food materials produced vary with soil conditions, the amount of fertilizer, and the season. Gould (*28 Pheasants*) [1] reports a planting project in New Hampshire in which nine food patches planted to various combinations of grains produced 746 pounds of seed per acre. Costs averaged $3.38 per hundred pounds of seed produced and $25.24 per acre. The most productive plot yielded 1,396 pounds per acre at a cost of $1.86 per hundred; corresponding values for the least productive plot were 235 pounds and $10.70. Where the food patches were planted, the pheasant population increased from 19 in September to 50 in November.

The growing of green manures to prevent the escape of soluble fertilizer material and to add humus to the soil is a common practice both on croplands and in orchards. Winter rye, soybeans, millets, cow peas, alfalfa, sweet clover, and lespedeza are all used for this purpose. In the orchard of the University of Massachusetts a mixture of soybeans and buckwheat has proved very satisfactory. These cover crops act as natural food patches of high value, especially for rabbits and pheasants.

Control of Harvest Operations. Harvesting of hay, grains, and corn is likely to be particularly destructive to both adult and young of many forms of wildlife. The nests of quail, ring-necked pheasants, Hungarian partridges, meadow larks, and numerous ground-nesting birds are frequently destroyed by the cutting bar of both the mower and the harvester, and all too commonly the incubating females are killed or maimed.

No farmer would willfully destroy the nest of any animal by cutting through it with a mower, but this type of destruction is unavoidable unless some device is used to flush the incubating bird in time to save the nest and reserve a surrounding island of hay. The flushing bar, devised by Peterson (22) and later modified by P. F. English (10), has done much to reduce such slaughter, in those places where the device has been used.

Figure 1·1, game bird flushing apparatus, illustrates such a device.

Other methods for saving game in hay- and grainfields have been suggested. One is to begin cutting operations on that side of the hayfield or grainfield farthest from cover so as gradually to force the game toward the cover and eventually into it. Another suggested procedure is to cut only part of the hay in any one field in a single day, leaving a reserve strip which is harvested later, the theory being that game forced into this strip by cutting operations will seek new cover if given time to do so. Another means of reducing loss is to provide other more attractive nesting sites.

[1] References followed by chapter titles will be found at the end of the chapter referred to.

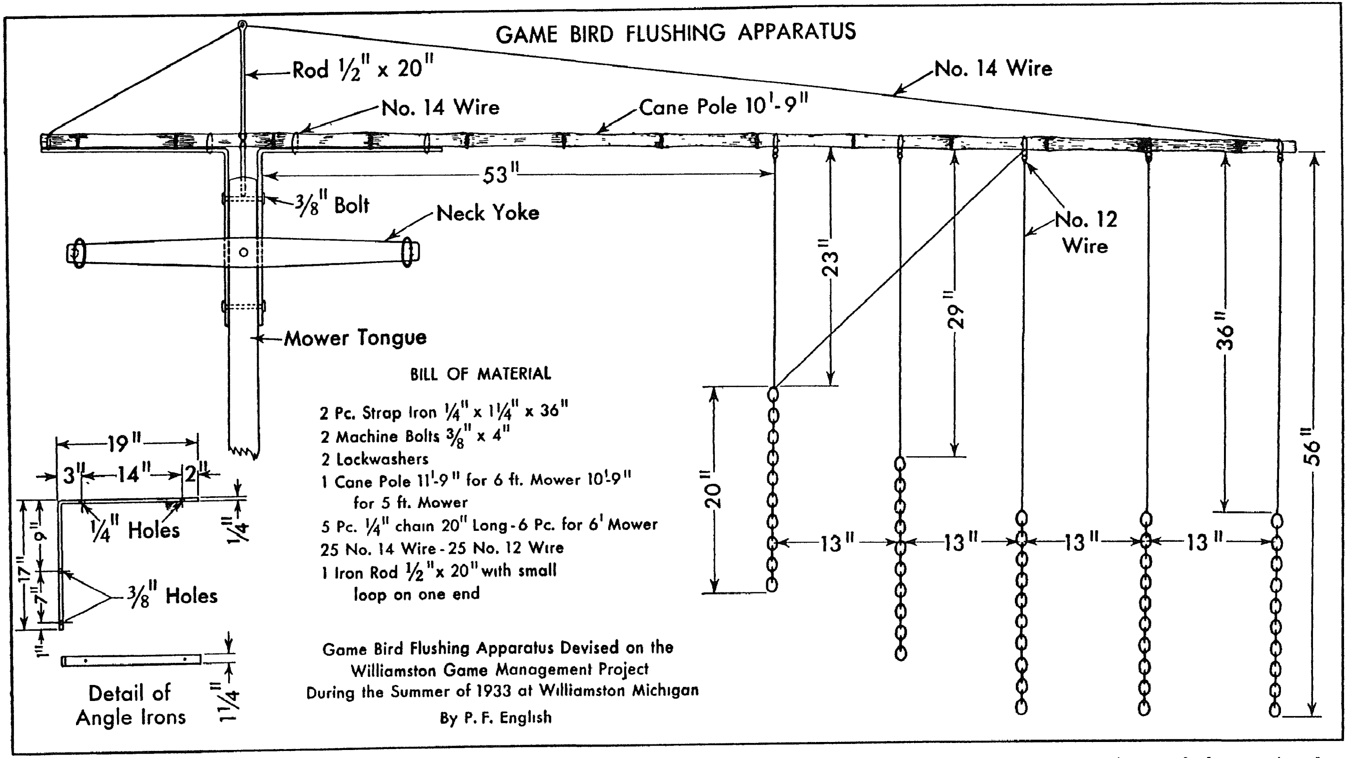

FIG. 1·1. This apparatus is attached to the tongue of a horse-drawn mowing machine. The chains dragging in front of the cutting bar flush the incubating bird before the cutter reaches it. An island of hay should be left to give the pheasant an opportunity to complete the process of incubating the eggs.

Leopold (*41 Pheasants*) believes that fence rows, unburned and unpastured marshes, and roadsides help but do not entirely solve the question of nesting losses (30).

Farm practices that defer harvest operations until later in the summer destroy fewer nests than an earlier harvest, because this procedure allows the nesting birds a longer period to hatch the clutch and leave the nest site. The increasing popularity of the combine, which cuts and threshes in one operation, is a step in this direction, for the combine functions properly only when grain is fully ripe, whereas the conventional method cuts and shocks it somewhat earlier. The late-season cutting of clover and alfalfa for seed is not unduly destructive, but the use of alfalfa for hay, with its attendant earlier harvest, has had the opposite effect. The practice of cutting alfalfa for meal and the advent of the mobile power-driven ensilage cutter has further increased the hazard. Cutting three instead of two crops of alfalfa is to be condemned as neither good agriculture nor sound wildlife management (25).

When grain is threshed in the field, the strawstack furnishes an excellent self-feeder for birds. Waste grain is usually sufficiently abundant in these stacks to last through at least part of the winter. As cover, the stack offers shelter to small birds, which bury themselves in the straw as protection against rigorous winter weather. Its value is enhanced considerably if it stands near cover. Fencing to prevent its being trampled by livestock is advisable.

Management of the Farm Wood Lot. The management of woodlands and its relation to the production of wildlife crops are treated in a separate chapter, *Wildlife Management in the Forest.* Much of the material presented there applies with equal aptness to the farm wood lot. However, certain aspects of the farm wood lot are emphasized here.

As an integral part of the farm economy, the wood lot, though small, has its place, supplying saw logs and a variety of other products such as posts, poles, crossties, and cordwood, which find an outlet either on the farm itself or elsewhere in the commercial market. Like the soil that produces the farm crops, the wood lot is a resource that must be conserved and protected. By careful and intelligent management it will serve its owner year after year. This condition is best satisfied if the wood lot is handled as a selection forest in which frequent light cuttings have as their objective the creation of several age classes and the development of a healthy reserve growing stock, perpetually maintained by a management policy that cuts only as much timber as the forest is growing. A wood lot managed in this way becomes a "going concern," which augments the farm income annually or periodically.

From the viewpoint of game management this type of woodland is equally desirable. Its diversity of cover and food conditions, its perma-

nence and relative stability make an ideal wildlife habitat, contrasting favorably with the more nearly uniform even-aged stands that develop on wood lots heavily cut at longer intervals. Managing the wood lot as an uneven-aged forest ensures a continuous supply of wood and wildlife crops.

Control of Erosion. Soil erosion and its control are subjects that have received wide attention in recent years (3). That erosion destroys topsoil, impairs productivity, and reduces property values needs no emphasis here. From the viewpoint of wildlife management, erosion is important chiefly because of its effect upon cover and food supplies. Gully erosion destroys both most effectively. Sheet erosion, which gradually removes topsoil and lowers fertility, though less spectacular than gully erosion, can be equally insidious in that cover quality and volume production of food materials become progressively less satisfactory.

Control measures take various forms that benefit wildlife directly not only by arresting the process of erosion but also by creating new cover and new food sources. The use of brush dams and the planting of herbaceous and woody species in gullies supply suitable cover for all farm game and frequently augment food supplies in the form of fruits and seeds. Fencing to exclude livestock helps to maintain cover and eliminates one of the causes of erosion. Once stabilized, gullies with suitable vegetational cover make excellent wildlife habitats, for such sites have little agricultural value and are likely to remain wooded perpetually. As nesting sites and escape cover for animals feeding on near-by cultivated lands, these spots possess high value. Rabbits, pheasants, bobwhite quail, and songbirds make good use of sites properly protected from erosion (18).

Development and Conservation of Water Supplies. A constant source of water is necessary for all types of life, human and otherwise. A high water level in the soil is a source of water for man, livestock, wild animals, and all plant life. Whenever a marshy area is drained, it affects the water level in the soil of the entire surrounding area. Abundant supplies of water in marshes and swamps ensure the maintenance of high water levels in near-by wells and promote the growth of a rich variety of trees, shrubs, and herbaceous plants. Stream and pond water levels are stabilized if water is not drained from all the low places in a neighborhood. Woodlands well intermixed with open farm lands prevent drying winds from sweeping across cultivated lands and drying out the soil.

Ponds can be created by building low dams across valleys, thus holding water from winter snows and spring rains that would otherwise escape. Dams may be of concrete, logs, or soil; but if soil is used, care must be taken to make the dam wide and the slopes gradual. A spillway for surplus water should lead around the dam so as to prevent washing of soil as the pond overflows, and all parts of the dam or by-pass must be sodded or planted to grass to prevent erosion. The dam and pond should be fenced against

a

b

FIG. 1·2. Soil conservation. Before (*a*) and after (*b*) soil conservation measures have been applied. Black locust trees have been planted and livestock have been kept away from this badly eroded hillside to prevent further loss of topsoil. The improvement and added attractiveness evident five seasons after application of conservation measures appear in the lower photograph. (*U.S. Soil Conservation Service.*)

livestock to prevent trampling. Willows or other water-loving shrubs and trees may be planted around the ponds to hold the soil in place and shade the water (21).

It is desirable to have as many places as possible on the farm where water can be obtained. Small springs with open outlets to brooks and ponds, stock tanks with a small overflow to keep a fresh pool of water available for birds, and bird baths on lawns, all are beneficial to the animal life on a farm.

Miscellaneous Recommendations. Major recommendations for improving the wildlife habitat for farm game have been discussed in the preceding sections. The recommendations that follow are less important but deserve consideration.

Plowing Operations. From the viewpoint of wildlife management, early spring is the most appropriate season for plowing croplands. Spring plowing at any time is preferable to fall plowing because the latter plows under winter food in the form of waste grain, crop residues, and weeds which frequently spring up following the harvest. Furthermore, stubble, weeds, and other refuse commonly present on unplowed fields provide valuable cover during the winter for birds that come to feed on waste grains and barnyard manure spread on the land. Plowed ground, on the other hand, affords no such protection. If any advantage can be claimed for fall plowing, it lies in the fact that no nests are present at that season to be destroyed by the plowing operation. When plowing is done in the spring, however, a certain amount of nest destruction is unavoidable. For this reason early spring plowing is better than late (25).

Care in the Use of Fire. The indiscriminate burning of grassland, fence rows, and wood lots is a time-honored practice on many farms, especially in the Southeast—and a decidedly undesirable one in all but a few special cases. Burning of this character not only serves no useful purpose but also destroys wildlife, vegetation, and other property and may induce unfavorable environmental changes which exert their ill effects long after all visible evidence of the fire has passed. If the farm is to serve as an attractive wildlife habitat, the use of uncontrolled fire must be eschewed (27).

This is no condemnation of the controlled use of fire, which has its place, but a word of caution is in order. All too frequently so-called "controlled fires," which seem so necessary to those responsible for their existence, are neither necessary nor controlled. The burning of brush, logging slash, and similar debris and other legitimate uses of fire should be undertaken only when complete control is possible. Such conditions exist following rain and whenever snow is present. Roadside burning, if it must be done, should take place in the fall.

Roadside Cutting. Roadsides and ditchbanks are especially attractive

as nesting sites for bobwhite quail, pheasants, and cottontail rabbits. The trimming back of such places for purposes of beautification should be done not earlier than mid-August to be the least destructive to nests. Under ordinary conditions if a roadside or ditchbank is trimmed in August, the one cutting suffices for the season, whereas an earlier cutting may not. Mowers for roadside cuttings should be equipped with flushing bars. Highway departments now favor the propagation of trees and flowering shrubs along main transportation arteries, and these make excellent wildlife production units. Cutting in such areas should be done with a thought to the preservation of desirable habitat conditions and the protection of wildlife.

Ditchbank Management. In much of the flat fertile lands of the Lake states, ditches and ditchbanks furnish the only locations on the farm where wildlife has an opportunity to find suitable living conditions. Drainage is essential on these flat lands, and ditch construction is an expensive operation; therefore ditch management should consider such items as the original cost as well as the kind of ditches and bank management that will keep the ditch in operation over the longest period and at the same time return the largest revenue for the area involved. For central Illinois conditions, Yeager and Yeatter (31) suggest a ditch with side slopes 2:1. A ditch 4 feet wide at the bottom and 4 feet deep will have a surface width of 20 feet and side slopes of about 9 feet. The soil removed should be leveled back, and the ditchbanks and bottom revegetated as soon as possible. One side may be planted to woody cover and the other to herbaceous plants to facilitate ditch repair and maintenance. Rye may be used as a cover crop to establish sweet clover, red clover, lespedeza, or Kentucky bluegrass. On the side on which woody plants are to be used, Asiatic rose (*Rosa multiflora*), Morrow's honeysuckle (*Lonicera morrowi*), coralberry (*Symphoricarpus* spp.), or hazelnut (*Corylus americana*) [1] may be used. Evergreens such as red pine, Norway spruce, and Douglas fir may be used either in clumps or as a hedge. Both shrubs and trees may be set in double rows 4 by 4 feet apart. If sod is heavy, it should be scalped off before planting the shrubs or trees. Fire and grazing will ruin any plantings and should not be allowed.

That ditchbanks may produce a revenue of considerable importance was shown on a demonstration plot in central Illinois, where the value of muskrat taken varied from a few dollars to $141.62 per mile. Yeager and Yeatter (31) give the average value of the ditchbank fur catch in Champaign

[1] Nomenclature of arborescent species according to "Textbook of Dendrology," William M. Harlow and Ellwood S. Harrar, 1941, and of nonarborescent species according to "Gray's New Manual of Botany," 7th ed., Benjamin L. Robinson and Merritt L. Fernald, 1908, and "Native Woody Plants of the United States," William R. Van Dersal, 1938.

County as $30 per lineal mile. This value does not include the increase of both song and game birds on managed ditch sites or the saving from longer life of the ditch as a drainage unit.

Emergency Winter Feeding. Supplying food to resident game from locally grown crops is the cheapest and easiest method of meeting emergency food shortages during the winter. A few shocks of corn placed along the edge of a wood lot, a few bundles of oats or bunches of soybeans thrown over a brush pile or stacked near a protected hedgerow often provide just the extra food so urgently needed during winter storms, when normal supplies become exhausted. By these simple expedients, the farm owner controls an emergency situation that otherwise might seriously deplete next year's game supply. For additional information on this subject consult the chapter on *Winter Feeding.*

Maps, Surveys, and Plans of Management. Intelligent management is greatly facilitated by the use of maps, the making of simple game surveys, and the formulation of concrete plans of game management. No tool of management is more useful and convenient than the map. As a permanent record depicting a large body of useful information in a form that is readily comprehended at a glance, the map has no equal. On it can be recorded such items as cover types (both natural and artificial); the location of food patches and perennial plantings; topographic features such as streams, ponds, swamps, and marshes; and cultural features like fence and hedgerows, windbreaks, waterholes, and strawstacks (see Fig. 1·3). A well-made map is, in itself, a reasonably good basis for management (29).

Surveys are of two types: the *game survey,* or census, by which the game manager determines his game population, and the *habitat survey* by which he determines the character and suitability of the farm as a game range. It is here the map serves so well as a simple means of recording the information obtained in the surveys. The game survey tells the farm owner what he has and where it is located approximately, the habitat survey forms the foundation for sound management. Cover and food deficiencies can be rectified only if they are known to exist, and only by such a survey can such weaknesses be discovered. Once the concepts of food and cover relationships and the individual requirements of each game animal are thoroughly understood, interpreting the surveys and making management plans are not difficult. For information concerning methods of taking a game census the reader is referred to discussions in the chapters devoted to individual animals.

A plan of management is, in a sense, a plan of attack. The game census and habitat survey provide the basic data. With definite knowledge of the game population and habitat conditions the farm owner is ready to plot his course of action. It may be a simple course aimed at hazy objectives or a very detailed one designed to obtain specific results within a given

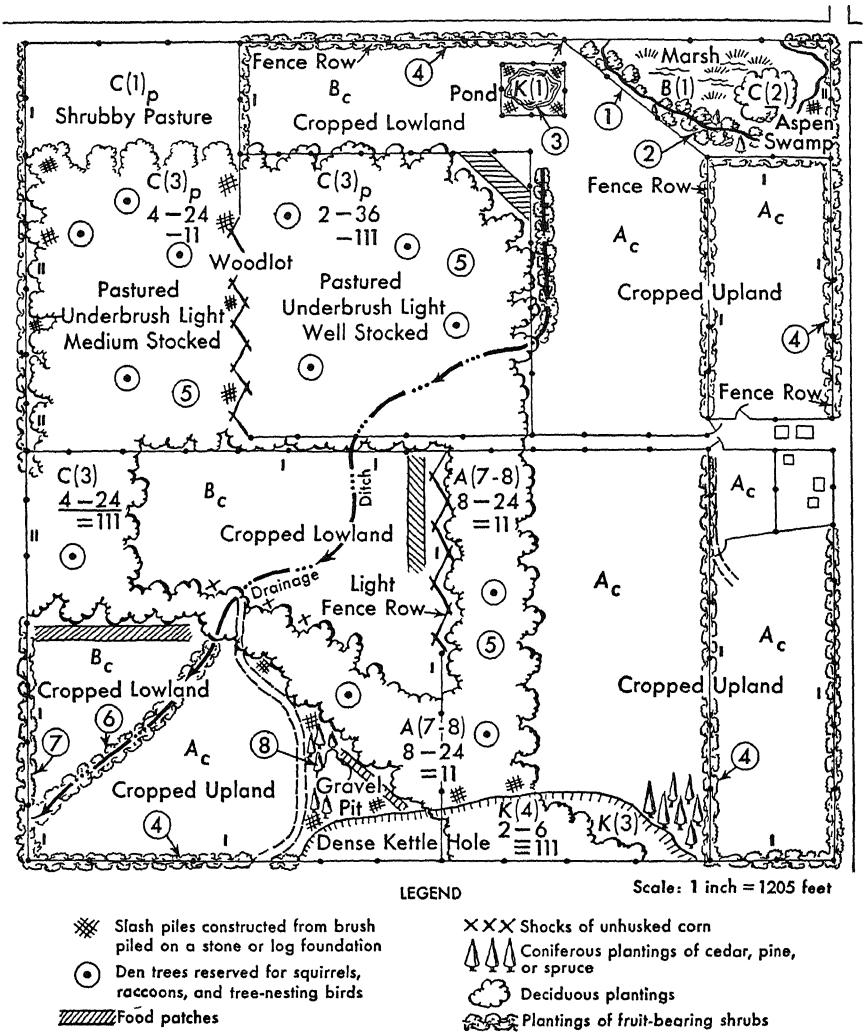

FIG. 1·3. Cover map and management plan for a square mile of farm land in southern Michigan showing cover types and topographic and cultural features affecting animal habitation with suggestions for the improvement of the land for wildlife.

period of time. In either case it possesses the elements of direction, order, and controlled administration—the elements of a plan of management. To be most effective it should be recorded in writing, stating objectives and the proposed program by which they are to be realized.

*

Explanation of Numbers on Map in Fig. 1·3

1. Fence to be constructed and then allowed to grow up to dense cover of perennial game food and cover plants.
2. Windbreak of conifers and hardwoods.
3. Kettle hole to be enclosed by fence. Plant aquatic food plants if not already established. To be used as habitat for muskrats and resting place for waterfowl.
4. Encourage growth of grape, alternate-leaved dogwood, hawthorn, etc.
5. Partial grazing to be allowed in woodlot on rotational basis, *i.e.*, every 10 years. If shrubby pasture does not provide adequate forage, then pasture improvement will be necessary.
6. Encourage or plant alder; allow high weeds and grass to grow on sides of ditch.
7. Encourage dense growth of food and cover plants suitable for use by rabbits, quail, and pheasants.
8. Gravel pit to be enclosed by coniferous plantings.

Origin from Land
Ac—Upland in crops
A (7–8) Oak—hickory—maple
Origin from Water
B(1)—Lowland submerged vegetation
Bc—Lowland in crops
Swamp Phase
C (1)—Shrubs
C (2)—Willow—aspen
C (3)—Elm—maple—ash woodland
C (3) p—Elm—maple—ash woodlands, pastured
Kettle Hole
K (1)—Grass
K (3)—Shrubs
K (4)—Trees
Timber Size
4—24, etc., range of timber diameters, breast high

Timber Stocking
Scattered —1
Medium —11
Dense —111
Very dense—1111
Underbrush Density
Scattered —
Medium =
Dense ≡
Very dense ≣
Fence Row Density
Clear or light—1
Medium —11
Heavy —111
Very heavy —1111
Miscellaneous
Cropped—*c*
Pastured—*p*

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CHAPTER II

COTTONTAIL RABBIT

(*Sylvilagus transitionalis* and *S. floridanus*)

GEOGRAPHICAL DISTRIBUTION

Cottontail rabbits are the most popular small game mammals in North America. No other animal is hunted so intensively for meat and sport or taken in such large numbers as the cottontail. The track of the cottontail in the first snow brings joy to the farm boy because it means fun in hunting and meat in the pot. As a game animal its popularity is largely due to its general abundance and widespread occurrence. Furthermore, it withstands hunting pressure surprisingly well and thrives in agricultural sections that are usually accessible to the majority of hunters.

Cottontail rabbits are found in all humid parts of the United States and during the past 100 years have extended their range into the agricultural sections of Canada. Distribution throughout most of their range is remarkably uniform, except in alpine or heavily forested regions where populations are sparse or lacking (33).

Anthony (*13 g.r.*) lists 30 species and subspecies of the genus *Sylvilagus*, all of which are known locally as cottontail rabbits. *Sylvilagus transitionalis* and the six subspecies of *S. floridanus* comprise the most important eastern representatives of this group. Four other species and subspecies, listed as swamp rabbits, occur on the Southern Coastal Plain. The remaining members of the genus inhabit the Rocky Mountain region and lands to the west.

The discussion that follows is based principally upon information relating specifically to conditions in the Lake states and the Northeast, particularly to the species *S. transitionalis*, which occurs in New England; *S. floridanus mallurus*, which inhabits the Atlantic Coastal Plain from Connecticut to northern Florida; and *S. floridanus mearnsi*, found in the Great Lakes region and states immediately to the south (34).

LIFE HISTORY AND ECOLOGY

Breeding Characteristics. The sex ratio among cottontails has been studied by several investigators whose findings, though conflicting in some instances, suggest that the ratio is probably about even (see Table 3). Although the tabulated results show the males predominating, this condition is perhaps more apparent than real. Trapping studies by which this

information was obtained were most frequently conducted during the winter, and at this season the females are less inclined to leave their dens than are the hardier males. Trautman (38) found in Ohio that 58 per cent of 391 rabbits taken from holes were females, and Gerstell's (20) work offers substantiating evidence that females are more sensitive to rigorous weather conditions than males. Since the winter season is also the hunting season, it seems probable that more males than females are killed by hunters, and as a result the sex ratio, if it exhibits any tendency to become unbalanced, would appear to favor the females.

TABLE 3. SUMMARY OF SEVEN STUDIES REPORTING INFORMATION CONCERNING THE SEX RATIO OF COTTONTAIL RABBITS

Author	Location	No. of rabbits	Per cent	
			Males	Females
Allen (3).	Michigan	196	51	49
Trippensee (39)	Michigan	216	57	43
Beule (9).	Pennsylvania	286	47	53
Beule (9).	Pennsylvania	200	47	53
Gerstell (20).	Pennsylvania	878	79	21
Dalke and Sime (14).	Connecticut	.	49	51
Schwartz (36).	Missouri	703	51	49

The normal breeding season extends from March to September (39) but may begin as early as January and continue until November,[1] varying with the locality and the lateness of the season (24). During this period the males pursue the females with great fervor. The pursuit appears to be motivated more by scent than sight, for it is observed more often on warm humid days when scent is easily followed. The time of day appears to be unimportant, for the author has observed this mating activity at midday and midnight. Mating is promiscuous.

The cup-shaped nest cavity is dug in the ground and lined with grass or other vegetation and fur from the mother's body. Beule (10, 11) found that nest cavities were dug from 4 to 14 days before the young were born and green grass was placed in the nest some time before it was needed. Nesting cover may be any of several types. Trippensee (39) found nests in 6 cover types in Michigan, and Beule (10) found them in 15 in Pennsylvania.

The period of gestation varies from 25 to 32 days (29). The normal period is 30 days for Middle Western species (22) and 28 for the New England cottontail (35). It seems probable that breeding is possible immediately following parturition. Two or three litters are commonly born in one

[1] Unpublished information made available to the author by Kenneth Wilson, formerly game technician for the Pennsylvania Game Commission.

season, and five are known to have been produced in southern Michigan (25, 27, 30). The average for Missouri is slightly less than four (36).

The litter varies in size from 3 to 8 rabbits but more frequently contains 4 or 5 (10, 24, 39). The productive capacity of a mature female during an single season approaches 25 where breeding conditions are ideal, but it seems improbable that this number is the rule. A more likely total is 12 to 18.

The young, which are blind at birth, remain in the nest for about 2 weeks. During this period the mother remains in the vicinity and ap-

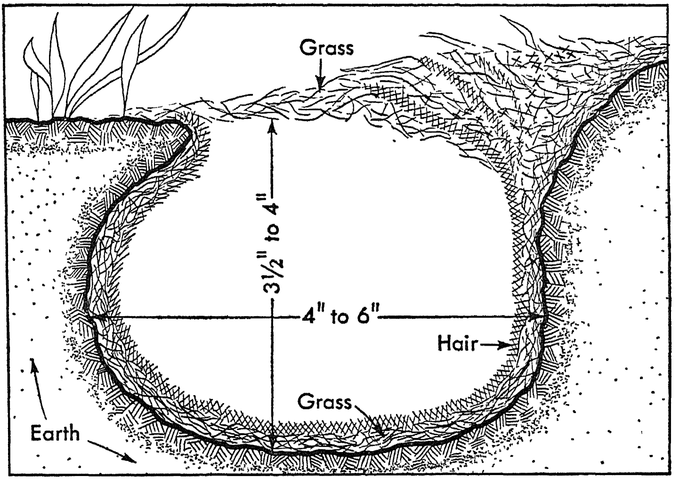

FIG. 2·1. Cross section of a cottontail nest. The nest cavity is lined with grass and fur. The young are well protected and completely concealed by this shelter when the nest is covered over.

proaches the nest only to suckle the young, dusk and dawn being the usual feeding periods. At other times the young fare for themselves, the nest supplying their only concealment and shelter. However, the mother defends the young if danger approaches, and on occasion she may remove her litter to another nest if conditions become too hazardous. The call alarm of a young rabbit is a series of intense high-pitched squeals. The mother rearranges the nest periodically, adding more grass and fur if needed (10). The plucking of fur from the mother's breast increases the warmth and softness of the nest and makes it easier for the young to nurse (24). The period of lactation is about 15 days (13). Eventually, the growing rabbits become strong enough to make short excursions from the nest, returning to it again, however, for several days more before leaving it permanently. Some investigators say the nest is abandoned at the end of the period of nursing.

Movements. The movements of cottontails are of four types: the dispersal movements of juvenile rabbits away from the nesting location in search of suitable range, routine daily movements in search of food and in response to disturbances, seasonal movements in response to seasonal food and cover requirements, and movements during the mating season. During the winter the rabbit population tends to concentrate in areas of protecting cover; but as spring approaches, it spreads out again. At times of low population densities the rabbits tend to concentrate in the better cover sites according to McCabe (32). The factors that motivate this thinning out of winter concentrations are not entirely understood, but it appears to be not entirely a matter of food and cover relationships. Mating instincts and habits seem to be partly responsible.

TABLE 4. SUMMARY OF TRAPPING STUDIES CONTAINING INFORMATION ON THE CRUISING RANGE OF ADULT RABBITS

Author and location	Sex	Known travel distance, ft.			Known range, acres		
		Av.	Min.	Max.	Av.	Min.	Max.
Schwartz (36) *	Male	291	97	910	1.4	0.17	4.0
Missouri	Female	410	97	991	1.2	0.15	4.9
Dalke and Sime (14)	Male	....	...	2,750	8.3	0.52	21.6
Connecticut	Female	....	...	1,560	2.9	0.59	8.4
Allen (3) †	Male	1,009	276	2,415	3.6	0.28	11.6
Michigan	Female	681	129	1,584	2.2	0.26	7.7

* Data include 99 per cent of the cases; the maximum travel distance of the remaining 1 per cent ranged from 1,322 to 3,477 feet

† January, February, and March.

The daily cruising radius of the cottontail is not known, although it very likely never exceeds a mile and is much shorter for the most part. Storms, cold weather, and other inclement conditions tend to restrict movements, and at such times the cruising radius is reduced to its minimum. During the spring mating season when males are roaming in search of females, it probably attains its maximum. Beule (9) speaks of tracking rabbits ½ mile on snow.

Several investigators (14, 25, 39) have published data concerning seasonal movements that are indicative, if not conclusive. In studies of this character, box traps (often 50 or more) are set at several well-distributed points within a given area; and as the rabbits are caught, each is tagged and then released. When a tagged animal is recaptured in another trap, it is known to have traveled at least the distance between the two traps; and if it is repeatedly caught, its movements can be interpreted.

It was found in Wisconsin that rabbits returned to a pothole from which they had been trapped if released not more than a mile away (4). The maximum reported dispersal distances of juvenile rabbits in Connecticut,

Pennsylvania, and Missouri are 2.4 miles (14), 1.8 miles (9), and 0.67 mile (36), respectively. The range used by female rabbits in Michigan is 17 acres during the winter and 15 acres during the breeding season (27).

Cover Requirements. Cottontails thrive on agricultural lands where cropland, grassland, woodland, and so-called "brushland" (cutover woodland and lands reverting to forest) are about equally represented and well distributed (*66 g.r.*, 26). An equal proportion of cropland is perhaps not essential provided it is well interspersed with the other vegetative types (19).

TABLE 5. AREA AND DISTRIBUTION OF COVER TYPES ON 500 ACRES OF THE W. K. KELLOGG BIRD SANCTUARY AND W. K. KELLOGG FARM NEAR BATTLE CREEK, MICH.(2)

Cover types	No. of units	Area, acres	Per cent of total area
Lowland brush	Many	8	1.6
Upland brush	7	10	2.0
Cropland	5	60	12.0
Dumps and stump fills	4	1	0.2
Grassland	Scattered	80	16.0
Marsh	7	10	2.0
Hay and pasture	Scattered	250	50.0
Coniferous planting	Scattered	20	4.0
Deciduous planting	2	3	0.6
Lowland woods	2	1	0.2
Upland woods	5	30	6.0
Open water	1	20	4.0
Unaccounted for	....	7	1.4
Total	....	500	100.0

The Kellogg Farm and Sanctuary is a good example of excellent rabbit range. The population for 1935 was slightly more than two rabbits per acre, which by ordinary standards is high.

One of the most favored items of cover is the burrow of a woodchuck, which serves as an avenue of escape and as shelter from storms and cold winter weather. Trautman (38) collected rabbits from woodchuck burrows in Ohio during the winter of 1933–1934, and Beule (9) found that rabbits remained on summer range throughout the winter when woodchuck dens were present, apparently preferring the burrows to natural vegetative cover. Burrows not only provide a dry retreat and protection against the wind but fluctuate less in temperature (40). Gerstell (23), investigating this phenomenon in Pennsylvania, obtained parallel temperature readings that fluctuated from − 8 to 74°F. in the open but only from 24 to 36°F. in a burrow 3 feet below ground level. Haugen (26) found that a larger than average number of rabbits wintered in upland sites where brush heaps had been provided. Brush heaps near fence rows were soon used and increased the local population.

Food. The food materials of the rabbit comprise a list of plants too long to enumerate here. They include succulent herbaceous materials, fruits, seeds, and the bark, buds, and foliage of woody plants.

A compilation of food plants listed in various publications shows a significant seasonal variation in food habits:

Season	No. of plant species		
	Trees	Shrubs	Herbs
Winter and spring..	66	54	6
Summer	15	11	49

Dalke and Sime (15) found three distinct feeding seasons in Connecticut. During the vegetative season from April through October feeding rabbits displayed a decided preference for herbaceous materials, which altogether formed 75 per cent of the summer diet; grasses alone comprised 44 per cent. November and December was a period of readjustment during which the diet underwent a gradual transition from principally herbaceous materials to the typical winter diet high in bark, roots, buds, and other parts of woody perennials. However, it seems likely that this change to a winter diet of woody plants is no evidence of a preference for such materials but occurs primarily because herbaceous plants are less abundant at that season. In Connecticut the 12 favorite winter species in order were blackberry, dewberry, gray birch, red maple, willow, black alder, mulberry, high-bush blueberry, low-bush blueberry, silky dogwood, swamp rose, and spiraea (37). The extensive use of sumac (*Rhus glabra*) in late winter by cottontails can be explained by the presence of its higher content of fat (12.52 per cent) as compared with the bark of other species (13).

A well-fed adult rabbit weighs between 2½ and 3½ pounds. Body weight varies with the season, being least in midwinter (36), and to some extent with the locality, the biggest rabbits being found on the most fertile soils (5, 6). Rabbits in Missouri are slightly smaller than those in Pennsylvania. Rabbits weighing less than 2 pounds are on the verge of starvation according to Beule (9) and are likely to die if subjected to unfavorable conditions.

Rabbits in captivity drink water freely, and under favorable circumstances some of them probably do so in the wild. However, water in the free state is not an essential part of their diet; and when it is lacking, they neither suffer any apparent injurious effects nor deviate from their normal mode of existence. Evidently their moisture requirements are entirely satisfied by the water in succulent plant materials.

Population Density. Rabbit populations reach their seasonal peak during summer and early fall. Habitat conditions at this season are at their

best, and the new crop of young rabbits has been added to the stock. During the winter and early spring, restricted carrying capacity of the range, hunting, and other factors of mortality reduce the population to its lowest point. The maximum productivity so far reported occurred on a 60-acre island in the Schuylkill River in Pennsylvania, where the population numbered better than five rabbits per acre (22). Trippensee (39) reported that 2,096 rabbits were shot in one season on Grosse Isle (6,681 acres), an island in the Detroit River, a kill of one rabbit for each 3.2 acres. The total population was undoubtedly larger, for part of the island was not hunted and elsewhere not all of the rabbits were killed. Gerstell (22) states that maximum production may approach one rabbit per acre on small areas of very favorable range, but on tracts as large as 1,500 acres, it is not likely to exceed one for each 3 acres.

MORTALITY

Rabbits are unusually prolific and produce relatively large numbers of young if the adverse forces of nature and the activities of man do not interfere. However, the factors of mortality are great, and even on highly favorable range the rabbit population is gradually reduced as the season advances. Thus on 160 acres of land Haugen (27) found that 11 females produced 156 young during one season. By August, however, there were only 31 young, or 1 out of 5 remaining for each litter, a loss of 80 per cent of the young. Many predators, both furred and feathered, depend to a considerable extent upon rabbits as a source of food. Carnivorous birds, like the goshawk, take a heavy toll, and, locally, tularemia and other cyclic diseases may virtually destroy an entire population in a short period (1, 32, 42).

Nest Destruction. After young rabbits are deposited in the nest, they are probably quite safe from the effects of the weather under normal conditions. But if they are born during the late winter when the mother is unable to build a satisfactory nest, they are likely to suffer heavy mortality (39). Exceptionally heavy rains of sufficient volume and intensity to saturate the ground are likely to flood the nest or cause death from exposure (24, 39). Snow and ice have been known to cause death by suffocation (30). Dogs, cats, and other carnivorous animals contribute to the losses. Beule (10) reports the following items of nest destruction:

Agent of Destruction	Number of Nests Destroyed
Man	3
Skunk	3
Flesh fly (*Wohlfahrtia vigil*)	2
Skunk and flesh fly	1
Weasel	1
Mice or shrews	1

Losses Due to the Elements. Young rabbits are not the only ones that suffer from exposure. Even adults are known to succumb under exceptionally adverse conditions, particularly if their resistance is low. In one case reported by Beule (9), 50 rabbits, underweight and weakened by shipment from another locality, were released in the winter; 8 were found dead a short time later. During snow and sleet storms rabbits sitting in their forms (resting spots in grass or similar cover) run the risk of being covered over and sealed beneath the snow. When this condition occurs, they are likely to perish. Rabbits in experimental pens in Storrs, Conn., were lost in this manner (31).[1]

Losses Caused by Predatory Birds. Great horned, barred, and snowy owls and marsh, red-tailed, red-shouldered, rough-legged, and broad-winged hawks may take rabbits when the opportunity presents itself.

It appears that the cottontail is a favorite food of the great horned owl, so consistently do rabbit remains occur in the pellets of this bird. Errington and his collaborators (*9 Predatory Relationships*) found rabbit remains in 66 per cent of the 543 pellets examined during eight winters in the north-central Lake states. Stomach analyses of 792 great horned owls in Pennsylvania disclosed that 41 per cent of the contents by volume consisted of cottontail rabbits and varying hares (*63 g.r*). This predator is not to be wholly condemned, however, because among its prey occur a number of other rabbit predators, including weasels, mink, skunks, opossums, mice, and several bird enemies. Furthermore, these owls are seldom found in concentrations greater than one pair to a square mile, and they reproduce slowly. Locally, this predator is often destructive, especially where woodland types predominate, but over the entire range of the cottontail their influence is probably not important.

The range of the snowy owl, which lies normally in the northern part of the continent, impinges upon that of the rabbit only when a shortage of food during the winter forces it to forage farther south. At such times snowy owls undoubtedly prey upon rabbits, but no evidence is available to indicate the extent of their depredations.

The marsh hawk feeds on mice normally, but very likely it may prey upon an occasional rabbit, particularly the young ones. Because this hawk hunts by day and the rabbit is active mainly at night, loss is likely to be greatest at dawn and dusk. Randall (*84 g.r.*) states that cottontails provide about 2 per cent of the fall food of this bird in Pennsylvania and somewhat more in the winter.

The eastern goshawk is a more serious predator than the marsh hawk. Rabbit may form as much as 15 per cent of its diet, second only to the gray squirrel, according to McDowell (*76 g.r.*). Forbush (*41 g.r.*) describes

[1] Unpublished information made available to the author by N. W. Hosley.

migrations of goshawks to the Northern part of the United States during the winters of 1896–1897, 1906–1907, and 1915–1916 and remarks upon their ability to track and kill rabbits, which they are able to decapitate as cleanly as if it were done with a knife.

Other predatory owls and hawks feed upon rabbits on occasion, but there is little evidence to indicate that depredations by these species are serious or other than desultory in character.

Losses Caused by Predatory Mammals. The fox and its relationship to the rabbit have long since become legendary, and with good reason, for

TABLE 6. SUMMARY OF FIVE STUDIES ON THE OCCURRENCE OF RABBIT REMAINS IN THE STOMACHS OF FOXES *

Author †	Location	No. of stomachs	Per cent containing rabbit remains
Hamilton	New York and New England	206	27
Hamilton	Massachusetts, Vermont, and New Hampshire	66	12
Errington	Wisconsin	46	48
Errington	Wisconsin	72	70
Errington	Iowa	40	68

* Both red and gray foxes included.
† See references on the red fox

supporting evidence is abundant. This animal is unquestionably the most serious enemy of the rabbit, killing it in great numbers, particularly during the winter when other staple foods like mice are less easily captured. Hickie (30) believes that the red fox is more than twice as destructive as any other mammalian predator, and in its diet only mice appear more frequently.

Weasels are known to prey upon young rabbits, but it seems doubtful if these animals destroy any appreciable number. The author has observed weasels following rabbits and knows of two cases where they were seen carrying rabbits, both immature. Dearborn (16) found rabbit present in 14 per cent of the 37 fecal and visceral samples of weasels that he examined.

The mink is a predator of some importance in winter (16), and skunks, badgers, raccoons, and opossums are known to take rabbits on occasions, but none can be considered persistently destructive.

Highway Losses. Of the many animals killed on our highways, cottontail rabbits are generally the most frequent victims. The annual mortality from this cause has been estimated to average 10 animals per mile of highway in highly productive range in Missouri (8), but it probably has no significant effect upon the total population (*66 g.r.*). Losses from this cause

are greater during the mating season and the period when juvenile rabbits are dispersing to new range.

Losses Due to Hunting. Hunting losses among game animals are expressed customarily as a percentage of the total population, but for losses among rabbits this mode of expression is infrequently used, mainly because the total population is rarely known. However, Allen (2) has published data concerning the hunting take on the W. K. Kellogg farm in southern Michigan that express losses in this manner. The take on this tract of 480 acres was as follows:

Year	Total population	Hunting take	Per cent of total
1935	228	154	67
1936	226	136	60

It appears that a residual population of 30 to 40 per cent at the close of the hunting season was sufficient to ensure a satisfactory crop the following year. Whether or not this reserve stock would suffice in all localities is problematical, for factors like range productivity and mortality from causes other than hunting are also factors that strongly influence the future crop.

The following comparison of the total hunting take for Pennsylvania is of interest because it not only shows the great number of rabbits killed during single seasons but also reflects a continuous decrease in population which the State Game Commission has since attempted to rectify.

Year	Hunting take	No. of acres per rabbit killed
1916	3,200,000	9.0
1922	3,645,000	7.9
1932	3,126,000	9.2
1933	2,290,000	12.5
1934	1,924,000	14.9
1935	1,971,000	14.5

Ohio estimated its kill for 1939 at 4,600,000, or one rabbit for each 5.7 acres.

Hickie (30) presents the following record of hunting pressure on two tracts of nearly equal size in Michigan:

Tract	Hunters per square mile	Hunting take per square mile	Hunting take per hunter
A	14.0	80	5.7
B	10.5	112	10.7

In Pennsylvania the average seasonal take per hunter was 11 in 1916 and 3.3 in 1935 (21).

Crippling Losses. No method has yet been devised for accurately determining crippling losses among rabbits, and the literature contains no estimates. That such losses are of considerable magnitude is certain. As any hunter knows, a scared rabbit on the run makes an elusive target, often hit but not killed, and more often than not, the injured animal dodges into a hole or stone wall before the hunter can take a second shot, there to die of its wounds or fall prey to a predator.

MANAGEMENT

Census. No reliable method for measuring a rabbit population has yet been devised. A number of procedures are in use, however, which give rough approximations, and for purposes of management these values are better than none (7).

One method estimates populations from the occurrence of "recent" fecal pellets on sample areas, a recent pellet being one on which the outer surface is quite intact and not badly weathered. Pellets of this character usually have been deposited within 3 months previous to the time of collection. In Ontario, MacLulich (*15 Varying Hare*) estimated that 9.5 recent pellets per square meter (1.13 per square foot) indicated 1,000 snowshoe hares per square mile. Hendrickson's (28) factor for cottontails on summer range in Iowa is 0.52 recent pellet per square foot per rabbit per acre. Beule (9), after trying the method in Pennsylvania, concluded that it is not suited to Eastern conditions, where changeable weather and variation in exposure caused by uneven topography have a variable effect on the durability of pellets. He feels that it is better adapted to dry climates in regions of relatively uniform level terrain.

Allen (2) has developed a method that is more nearly accurate perhaps than any other, but its application is both expensive and involved. During the fall he traps and tags a portion of the population inhabiting a given area. Next he tallies the number killed during the hunting season, separating the tally of tagged from untagged. The estimated population prior to the hunting season is then determined by a simple proportion:

$$\frac{\text{Number of marked rabbits shot}}{\text{Total number of rabbits shot}} = \frac{\text{total number of marked rabbits}}{\text{total rabbit population}}$$

His calculations for the W. K. Kellogg farm were made by this method: $57/126 = 102/X$, the calculated total population thus being 226. Where hunting is not permitted or the take is not easily ascertained, the method may be modified to overcome this handicap by substituting a second period of trapping in place of the hunting take. The population then can be calculated as follows:

$$\frac{\text{Number of marked rabbits recaptured}}{\text{Total number of rabbits trapped during the second trapping period}} = \frac{\text{total number of marked rabbits}}{\text{total rabbit population}}$$

Even though no satisfactory means are available for calculating the population in absolute numbers, trends in the population from year to year can be inferred from studies of the annual hunting take for a given area. A declining take reflects a declining population, and vice versa. The record of the annual kill in Pennsylvania (see page 32) is an example.

Relative densities of populations, *i.e.*, the abundance of rabbits on one area relative to their abundance on other areas, can be approximated roughly by comparing "signs." Pellet counts, although of questionable value as determinants of rabbit population in absolute numbers, are fair indicators of relative numbers (41). Counting tracks on snow and signs of feeding such as gnawing of bark and clipping of twigs are other means to the same end. The first procedure is practical where populations are thin, but among heavier concentrations tracks are so intermingled that separation becomes virtually impossible.

Evaluating the Rabbit Range. The usefulness of "yardsticks" for measuring range quality is discussed in Chap. IV on *Pheasants*. Because the method about to be described (18) is an adaptation of the procedure recommended by Professor H. M. Wight for the pheasant, it is suggested that the student read that section before proceeding with the discussion that follows.

TABLE 7. PLAN FOR RATING COTTONTAIL RABBIT RANGE, SHOWING THE BASIS OF EVALUATION AND THE SPREAD OF EVALUATING UNITS

Basis of evaluation	Rating on basis of number		Rating on basis of size and quality				Combined rating *
	Number to the square mile	Standard rating	1	2	3	Av.	
Nesting sites	40	0–15	—	—	—	—	0–15
Units of resting cover	100	0–15	—	—	—	—	0–15
Units of escape cover	100	0–20	—	—	—	—	0–20
Winter food units	100	0–10	—	—	—	—	0–10
Interspersion of units	...	....	..	..	..	..	0–10
Distribution of units	...	....	..	..	..	..	0–10
Adaptation to management	...	....	..	..	..	..	0–10
Communication (travel lanes)	...	....	..	..	..	..	0–10
Total	...	....	..	..	..	..	0–100

* "Rating on basis of number" divided by "rating on basis of size and quality"

Basis for Final Ratings

Sum of Combined Ratings	Final Rating
1–25	IV
26–50	III
51–75	II
76–100	I

Explanation

1. The standard number of food and cover units represents what Dugan (18) believes to be the requirements for a winter carrying capacity of 100 rabbits per square mile.

2. Nesting cover (herbaceous types) 4 chains in length = 1 unit; a unit 50 feet wide merits the maximum rating on the basis of size; quality of cover is judged by the degree of concealment it affords.

3. Resting cover (thickets) 1 chain in length = 1 unit when the cover type is long and narrow as along fence rows, in patches 1 acre = 5 units.

4. Escape cover (ground dens, evergreen clumps, junk heaps, brush and rock piles, etc.) capable of harboring one rabbit under winter conditions = 1 unit; judging the capacity of each item is largely a matter of personal appraisal based on experience.

5. Winter food types (areas of sumac, dogwood, brambles, hardwood seedlings and small saplings, etc.) 10 chains in length and averaging 7 feet wide = 1 unit, in patches 1 acre = 10 units.

6. Distribution of units is judged by tallying units separately for each quarter section (see Table 8).

Table 8. Sample Rating Sheet for Evaluating Cottontail Rabbit Range [Adopted from Dugan (18)]

Basis of evaluation	Rating on basis of number						Rating on basis of size and quality				Combined rating
	Tally of units by quarter sections				Total rating						
							1	2	3	Av.	
Nesting sites (40).......	2	5	6	8	21	8.0	5	10	6	2.0	4.0
Units of resting cover (100)	0	3	11	25	39	6.0	10	20	9	2.0	3.0
Units of escape cover (100)	0	0	7	4	11	2.0	3	5	3	2 0	1.0
Winter food units (100) .	0	21	6	4	31	3.0	20	5	6	1.0	3.0
Interspersion of units....	....				....		..	..	..	...	2.0
Distribution of units.. .	....				....		..	..	..	...	5.0
Adaptation to management................	....				....		..	..	.	...	2.0
Communication (travel lanes)...............	....				....		.	..	.	...	1.0
Total.......	....				... .		..	..	.	...	21.0
Final rating........	....				....		..	..	..	...	IV

Food and Cover Development. The successful management of the cottontail rabbit depends to a large extent upon the availability of suitable food and cover during the winter. In the eastern part of the United States there is generally such good interspersion of open lands and brushy covers that a favorable all-season condition seems to be present for cottontails.

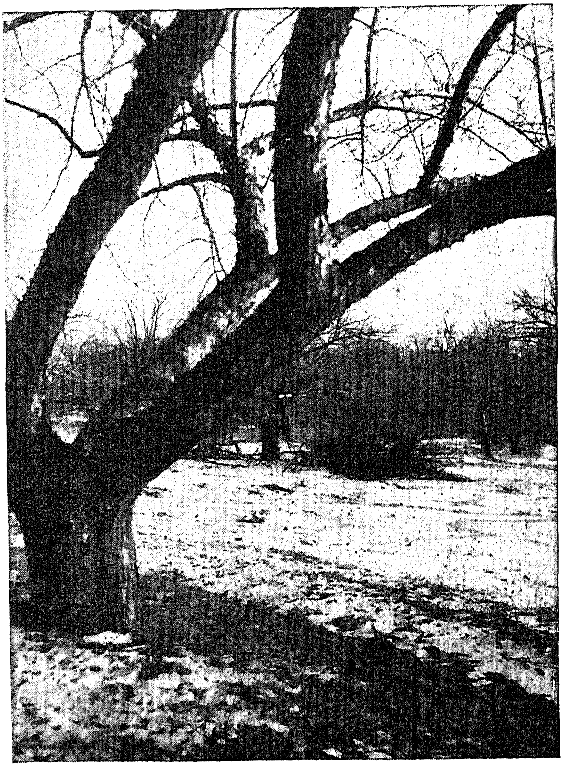

FIG. 2·2. Material pruned from apple trees makes excellent winter food and cover for rabbits. These prunings if left on the ground until spring may prevent damage to young trees. (*Photograph by Gordon T. Woods.*)

In the Middle Western agricultural states, however, the problem is chiefly a deficiency of winter cover.

The development of supplemental food is needed primarily in localities where the rabbit population is forced to rely upon bark, buds, or similar woody materials as its principal source of winter nourishment. Succulent materials like rye or winter wheat are desirable additions to the diet of woody materials. Well-fed rabbits maintained upon this diet during the winter are likely to remain in better condition than those fed on the customary materials of woody origin.

Food patches placed near suitable cover also help to solve the problem

very satisfactorily. Alfalfa, clover, vetch, soybeans, and corn are excellent for this purpose. A number of these plants when piled over brush, logs, or stones provide both food and a shelter in which the rabbits can feed in comparative safety. As the winter advances, food supplies can be supplemented further by placing additional stores of unhusked corn on or near these piled-up ricks. On lands lacking woody perennials in satisfactory numbers, hawthorn, willow, aspen, climbing nightshade, sumac, smilax, bittersweet, and other vines may be propagated as an emergency ration in the event that adverse weather or other factors render normal supplies useless.

Orchardists have long protected young fruit trees from rabbits by allowing pruned branches to remain on the ground until after the snow has melted in the spring. Rabbits feed upon these materials, find shelter under them, and as a result are less likely to attack the standing trees. When pruned branches are not required as protection in the orchard, they can be utilized to good advantage if dropped in loose piles along woodland borders, where they add cover and augment the winter food supply.

Weeding operations, thinnings, and improvement cuttings in the farm wood lot have much the same effect, supplying cut stems, branches, and sprout growth, which are of considerable value for winter food for rabbits.

The development of cover is a problem likely to be less important in the East, where woody types are both common and well distributed, but westward this problem is frequently a crucial factor. Fencing wood lots, marshes, and kettle holes to exclude livestock and the reservation of land along fences and in odd corners on which natural vegetative cover is allowed to develop alleviate this cover deficiency in some cases, but in others the establishment of plantations and windbreaks is desirable and necessary (see Fig. 2·3).

Michigan, Ohio, and Pennsylvania now have under trial programs of range improvement that apply many of the recommendations suggested in these pages. Ohio has set aside propagation areas of 75 to 250 acres in each county. Each has a suitable combination of woody cover and open fields. Cover crops of alfalfa, clover, timothy, and sudan grass are usually present. Winter wheat and rye are often planted for the succulent greens they provide during the winter and early spring. Grain crops like soybeans, late corn, and sunflowers are planted in food patches of an acre each. Soybeans and alfalfa are stacked on loose piles of brush and covered with unhusked corn. Groundhogs are encouraged to remain in the area and are frequently transplanted to it, because their burrows provide the rabbits with shelter from winter storms. No hunting is allowed on these tracts.

A similar program designed to serve all small game animals was undertaken by the Pennsylvania Game Commission in 1937. Environmental improvement consists primarily of planting evergreens, fruit-bearing vines

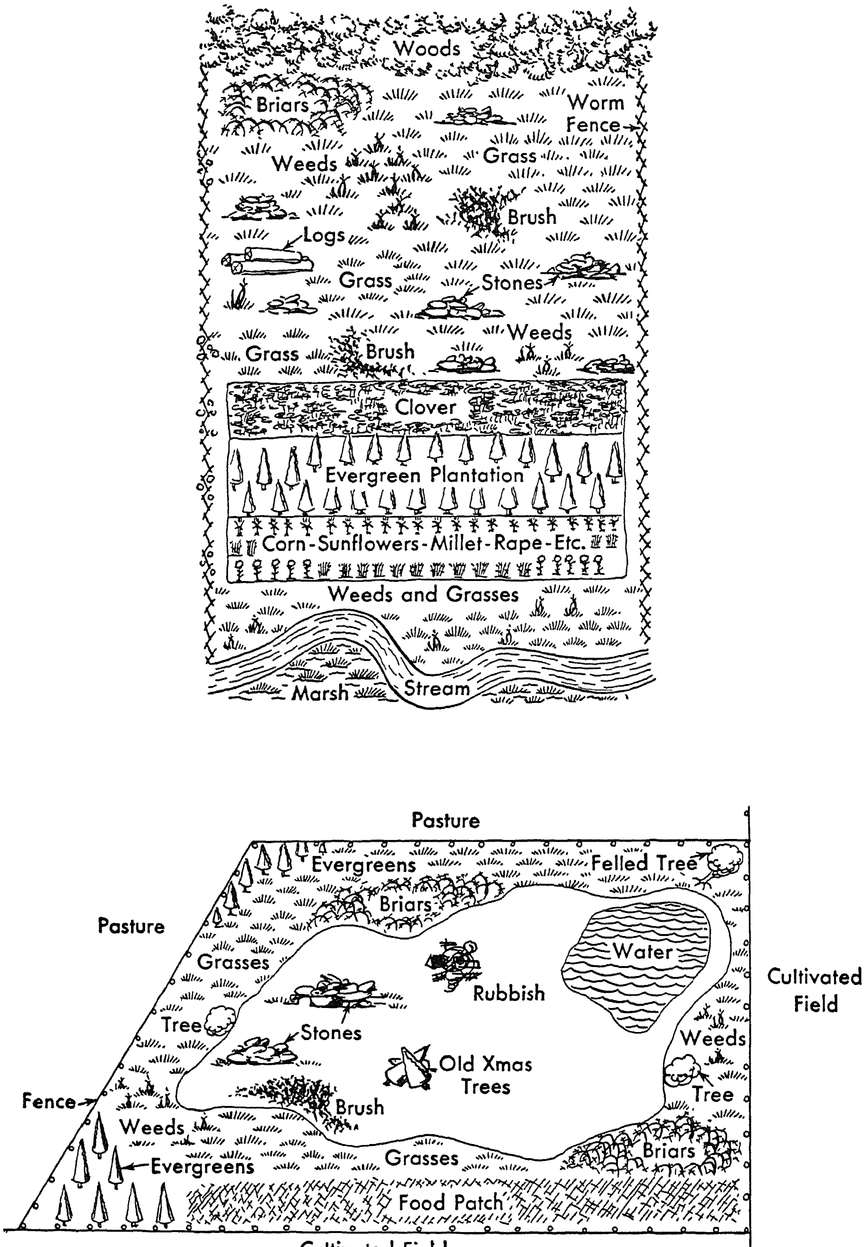

FIG. 2·3. Diagrams of range improvements for cottontail rabbits. The ideal range for the cottontail must contain high-quality foods and cover suitable for protection from the weather and escape from winged and ground predators all in a minimum of space. (*Diagram by Richard Gerstell*, 20, 21, 22)

and shrubs, and annual cover of plants like sudan grass and corn. On Sept. 1, 1941, 100 propagation areas aggregating 30,597 acres had been established.[1] Reserved areas have been so productive that surplus stock is trapped for redistribution about the state. During the 1939–1940 season, over 31,000 rabbits were captured and transferred in this manner, most of them coming from propagation area and public parks (12).

Predator Control. Two predators are sufficiently destructive to warrant control measures: the fox and the great horned owl. Others may be dismissed without further consideration. The fox is best controlled by trapping during the season when its fur is prime; shooting and destruction of nests take care of the owls.

Miscellaneous Management Procedures. The cottontail rabbit, like most game animals, becomes destructive if its numbers are permitted to increase indefinitely. Cultivated crops and forest seedlings both suffer when the population passes a certain critical point. When that level is exceeded, control measures become necessary. Hunting, trapping, and netting the animals from their dens are possible methods. The captured rabbits can be sold to private preserves or transferred to public hunting grounds where populations need replenishing (17). Trautman (38) captured as many as 40 rabbits in a single day, using three ferrets and a crew of four men. The rabbits, driven from their holes by the ferrets, were caught in a net as they came out. For trapping, the simple box trap is an efficient device for removing rabbits from locations where harm is being done to agricultural crops.

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CHAPTER III

HUNGARIAN PARTRIDGE

(*Perdix perdix perdix*)

Geographical Distribution. The Hungarian or gray partridge is one of two exotic game birds that have been transplanted successfully to North America. This little gray cannon ball from the plains country of southeastern Europe and western Asia and the more gaudily plumaged pheasant are the only two among a score or more of introduced game birds that have taken kindly to their new home in the Western Hemisphere. While "hope springs eternal" in the minds of sportsmen each time money is appropriated for the introduction of a new game bird, past evidence indicates that the chances of success are very limited. But efforts to establish the Hungarian partridge proved an exception. The first importation of Hungarians was made sometime previous to 1800 near Beverly, N.J., by Richard Bache, a son-in-law of Benjamin Franklin (*83 g.r.*). Since then almost every state in the Union has tried to stock these birds, often at tremendous expense and usually without success (6). Between 1900 and 1932 about 268,000 birds were released in various parts of the North American continent (2, 19). During an interval of 15 years, Pennsylvania alone spent $131,000 to stock some 33,000 birds, few of which became established (5). The most marked success has been achieved in the prairie provinces of Canada, where results have been spectacular. Eight hundred birds released about 1908 in Alberta have since spread in all directions and multiplied prolifically, the present population in that province, Saskatchewan, and Manitoba owing its existence to the original 800 (6). W. B. Mershon of Saginaw, Mich., reported flushing more than 1,000 birds in a single day in that region (6). Seth Gordon (6) says the Hungarian is now established in four provinces and 13 states. None of the establishments in the United States have been as successful as those in Canada, but excellent hunting is available in limited localities within five states.

The Hungarian partridge is intermediate in size between the bobwhite quail and the ruffed grouse. Its weight is about 13 ounces at maturity. The over-all appearance of the plumage is brownish-gray marked with black on the back and yellowish-chestnut on the head, with lighter shades, predominantly gray, on the chest, sides, and neck. The feathers of the sides and flanks are heavily barred with dark chestnut. The outer tail feathers are reddish-brown, a conspicuous field mark when the birds are in

FIG. 3·1. Range of the Hungarian partridge. (*From Charles F. Yocom, 1943.*)

flight. Adult males and some juvenile females have chestnut-colored horseshoe markings on the lower breast. This mark disappears from the female after the first year but remains permanently on the males. Juvenile females may be distinguished from the males by markings on the wing coverts.

Buff crossbars appear on the female only. On the male the distinctive mark is a longitudinal cream-colored feather shaft stripe.

Hungarian partridges are now established in British Columbia, Alberta, Saskatchewan, Manitoba, Washington, northern Oregon, western Idaho, northern Montana, North and South Dakota, southern Minnesota, northern Iowa, southeastern Wisconsin (12), northeastern Illinois, southern Michigan, northeastern Indiana, and northwestern Ohio. Successful local colonies are found in Pennsylvania, New York, New Jersey, Connecticut, and Prince Edward Island (3). In general the birds have been successful in regions where soil is fertile and domestic grains are grown intensively. The most northern areas having short summer seasons but soil sufficiently fertile to raise small grains and a good crop of weeds seem to be the most suitable type of environment. Extremely high summer temperatures have an adverse effect. Drought is not well endured. However, the exact factors that limit distribution are not known. Low temperatures do not appear to restrict its distribution northward (19).

LIFE HISTORY AND ECOLOGY

Breeding Characteristics. In many of its habits, especially its breeding characteristics, the Hungarian partridge resembles the bobwhite quail. Both birds are in the family *Perdicidae.*

Mating. The Hungarian partridge is monogamous, and the bond between mates is strong, extending into the summer and autumn long after mating is complete. Mating begins during the first warm days in late winter when the coveys in which these birds congregate at this season begin to break up and mates are selected. Late January and February mark the beginning of this period in the Middle West (7, 19, 20), and farther north it commences progressively later. During the mating period fights between males are of common occurrence. Ordinarily, both birds in a mated pair come from a single covey, but in some cases apparently there is an interchange of individuals between coveys, thus ensuring a better mixing of breeding stock (20).

Nesting. The nest of a Hungarian partridge is a shallow depression in the ground scratched out to receive the eggs. Whether only the female or both sexes prepare the nest is not certain. Yocom (20), however, says the female builds the nest while the male stands guard. The nest cavity is lined with plant debris in two layers, the basic layer being coarse material such as straw and plant stems. The lining is of finer material such as the leaves of grains, weeds, and native grasses. The nest is better lined when an abundance of materials is available and may be partly covered over, even to the extent of having an entrance. Nesting activity is begun any time after mid-April and reaches its height during May in southern Michigan and probably later farther north. Mated birds tend to nest near winter

feeding grounds if suitable cover occurs close by, such cover consisting of hay, weeds, dead grass, grains, or any natural vegetation of low stature that has developed sufficiently to conceal an incubating bird (19, 20). Hayfields, grainfields, grassy swales, roadsides, fence rows, and ditchbanks all may serve as nesting ground (Table 9).

TABLE 9. CHOICE OF NESTING SITES IN SOUTHERN MICHIGAN BASED ON OBSERVATIONS OVER A 3-YEAR PERIOD (19)

Cover type	No. of nests	Per cent of total
Hayfields	48	34
Grainfields	29	20
Fence rows	27	19
Roadsides	17	12
Ditchbanks	5	3
All others	17	12
Total	143	100

The preference for hayfields is not so pronounced as the values in Table 9 imply. For example, on one study area in Wisconsin only 12 per cent of the nests observed were found in cover of this composition despite its large aggregate area, which exceeded that of other natural types by seven times (9). On the basis of comparative areas it appears that hay- and grainfields are less favored than native vegetation such as grass, scattered herbaceous growth, or low woody plant communities along fence rows or in ditches, potholes, and similar locations. As an illustration, Hawkins found that nests occurred in roadside copses at the rate of one nest to ½ acre, but in tame hay the average was one to 90 acres. Natural cover with an abundance of dead plant materials seemed to be preferred. Yocom (20) states more than 25 per cent of the nests in Washington are located in hayfields. In general nests are located near the border of a cover type (13). Yeatter's report of studies in Michigan states that half the nests observed in fields were located in the outer 24 feet, only 6 per cent of the nests farther in than 100 feet.

Egg laying begins soon after the nest is finished, May and June being the months of greatest activity. Occasionally two birds may deposit their clutch in a single nest, and in some localities pheasants may lay eggs in partridge nests (20). The average clutch contains from 16 to 18 eggs, sometimes fewer (13, 17, 19). Clutches containing up to 25 eggs have been reported, but these are believed to be the eggs of two females using the same nest (19, 20). The number of eggs in a clutch apparently varies with the time of year, growing smaller as the season progresses. Yeatter found that clutches laid in June averaged 19 but fell to 15 in July and 9 in August.

The average clutch at Pullman, Wash., for two years, 1940–1941, was 17 eggs (20). Only females incubate the eggs, 21 to 24 days (13, 20, *66 g.r.*) being the time required. The female leaves her nest in the morning and evening to feed; but when the eggs are ready to hatch, she may remain on the nest for a day or more until the process is finished. In the Palouse region of Washington the height of the hatching period is the middle of June (20). Hatching is mostly over by mid-July.

Rearing the Young. The male Hungarian partridge remains near the nest during the incubation period and helps rear the young when incubation is completed. Both parents assume responsibility for the brood, and when traveling across open ground the mother has been observed to lead the way, followed in single file by the newly hatched young and finally the male. The young develop rapidly and in about 110 days are full grown.

Movements. Daily movements are quite short under natural undisturbed conditions and are concerned chiefly with routine matters of everyday existence such as securing food, resting, and dusting. Feeding takes place twice daily, once in the early morning from dawn until 8 or 9 o'clock and again in the evening. The remaining daylight hours are spent in intermittent feeding, dusting, and resting, often in the shade of protective cover. Roosting is restricted to the ground, commonly in open fields of stubble, grassland, or standing corn. The movements of the coveys are apparently more restricted in fall and winter to definite territories where grains or weed seeds, succulent vegetation, and grit are available. Shortages of any of these materials will cause the coveys to travel in search of them. According to Yeatter (19), the cruising radius, which is the distance between points at which the same covey may be found, during the winter period may be as short as ⅛ mile or as long as ½ mile. Yocom (20) indicated that 75 per cent of the coveys moved less than ¼ mile in the Palouse region of Washington. Hungarians are strong fliers and under stress of necessity may fly very rapidly for distances up to ½ mile. The entire covey usually takes off together, flying low and, if hills are present, disappearing from sight over a near-by ridge. When flushed again the covey will be together (20).

There is no true migration, but Hungarian partridges placed in an environment unsuited to their requirements soon move on in an attempt to find a more favorable habitat. Leopold (*66 g.r.*) states that the maximum rate of spread in Canada was 400 miles in 14 years, or 28 miles per year. Dispersal in northern Ohio and southern Michigan has been proceeding at 3.5 to 5 miles a year (19). Some birds may travel as far as 50 miles in a year (12).

Partridges normally remain in coveys except during the breeding season, at which time they are found in pairs. How great an intermingling of coveys occurs or transfer of individuals from one covey to another has

not been accurately determined. Yocom (20) reported an increase of coveys following the fifth week after hatching, indicating a combining of broods. The average size of coveys enumerated by Hammond (8) in North Dakota ranged from 8.2 to 13.0 birds, being greatest in the brood stage and smallest prior to the period of mating.

Cover Requirements. The sections of North America where Hungarian partridges have become well established are the great grain-producing regions of the continent where natural cover is often scarce or absent. In places it is virtually nonexistent; yet the partridges survive. This is not the ideal situation, but it serves to demonstrate the adaptable nature of the bird and suggests that small units of suitable cover well distributed help to sustain a thriving population. Maximum carrying capacity is probably attained on farms devoted to the production of grain but so managed that small units of grasslands, weeds, and brushy patches occur interspersed among the grainfields to provide nesting cover and protection from adverse weather and certain predators.

The use of hayfields as nesting cover with the inevitable loss of nests through mowing tends to limit partridge production even on good partridge range. This use of hay- and grainfields for nesting may indicate the lack of other and safer cover for nesting purposes or possibly a choice of grasslike crops for this activity.

Cover also is important in winter. No other game bird is so well fitted to withstand the vigorous winters that characterize the regions inhabited by the Hungarian partridge, but despite this amazing durability it requires a modicum of shelter to which it can retire when conditions are more severe than usual. Protection against winds is vital. Cover for this purpose need not be extensive or tall as long as it covers the birds. Standing sweet clover is said to be excellent (8). Natural cover of native plants is entirely satisfactory (19, 20).

The exact importance of cover to the Hungarian has not yet been determined. In all parts of the partridge range, cover is used when available, yet heavy populations of Hungarians continue to exist on the open wheatlands of the Canadian prairie provinces. More study is needed to find the relationship of this unusual bird to its new environment in North America. Certainly, with the possible exception of the woodchuck, no other farm-game animal maintains as thriving a population with so little cover.

Food. Except among juvenile birds less than 1 month old, the diet of the Hungarian partridge contains very little food of animal origin. Fundamentally, it is vegetarian, animal matter, mostly insects, comprising perhaps one-twentieth of the year's total consumption (11). In summer animal food may form 10 to 15 per cent. Among newly hatched birds, insects are eaten almost exclusively at first, but by the fourth week the

principal dietary items are vegetable. This change in juvenile food habits is well demonstrated by data secured in England (1). The percentage of animal matter for each of the first 4 weeks was 95, 91, 52, and 3 per cent respectively.

The food of adult birds is derived mainly from the by-products of agriculture: waste grain, weed seeds, leaves of grasses, and grain plants. Grains are important chiefly in late autumn, winter, and early spring; weed seeds at all seasons except in late spring and early summer; green leaves in

TABLE 10. FOOD HABITS OF ADULT HUNGARIAN PARTRIDGES IN ENGLAND EXPRESSED IN PER CENT BY VOLUME (18) *

Type of food	Sept.	Oct.–Nov.	Dec.–Feb.	Mar–May	June–Aug.	Av.
	177 crops	175 crops	34 crops	12 crops	31 crops	429 crops
Grass, clover, and leaves ..	9.9	26.5	68.0	92.2	14.3	42.2
Flowers and buds.	0.9	0.2	.	6.0	28.7	7.2
Roots (sugar beets, etc.)...	0.4	16.4	13.3	0.5	....	6.1
Seeds (grasses and weeds)..	11.9	34.5	17.8	1.2	38.5	20.8
Grains (wheat, barley, oats, and buckwheat)........	76.3	22.4	0.7	0.1	6.5	21.2
Animal foods (mainly insects).......	0.6	0.04	. ..	0.02	11.8	2.5

* Total percentages do not equal 100 in all cases Data given as originally published.

late spring, summer, and early autumn. These three items ordinarily make up 80 to 90 per cent of the entire diet. In Washington the fall food is about 89 per cent grain and 7 per cent green material. The remaining 4 per cent is seeds of grass, weeds, and a small amount of animal food. In winter, grains are eaten to a less extent and green material is used more extensively (20). The food habits of the Hungarian in England, where it has been longer established than on this continent, appear in Table 10. Anyone interpreting the table should bear in mind that conditions in England differ from those here in that the climate is warmer and more moist, snow is uncommon in winter, and succulent herbaceous growth is more abundant because a greater portion of the arable land is devoted to growing of cool-weather grains and root crops.

The principal food items reported in Michigan as given by Yeatter (19) include domestic grains (especially corn), barley, wheat, and oats; seeds of ragweed, green and yellow foxtail, black bindweed, lamb's quarters, and finger grass; and leaves of grain, shoots, clover, dandelion, alfalfa, and bluegrass. The last group was eaten mainly in the late spring and summer; the grains and weed seeds from autumn through early spring. In Ohio much

the same pattern is evident (10). In studies reported by Hicks (10) grains and weed seeds formed 74 per cent of the winter diet; leaves and other herbaceous material the remainder. Corn was the favorite grain, consumed almost exclusively during the season of harvest. Grains eaten in smaller quantities were wheat, buckwheat, and soybeans. Hawkins (9) gives the amount of food eaten by adult Hungarians as about a pound per week.

A summary of the food habits of Hungarians in Washington is given in Table 11.

TABLE 11. SEASONAL FOOD OF THE HUNGARIAN PARTRIDGE IN WASHINGTON (20) BASED ON PER CENT OF TOTAL CROP VOLUMES *

Season	Animal food	Vegetable food					
		Total	Grain	Grasses and weed seeds	Green matter	Grit	Misc
Summer.......	13.03	86.77	42.45	38.41	4.60	0.30	1.31
Fall......... .	0.06	95.72	88.83	3.68	6.89	0.00	0.00
Winter.	None	99.91	62.05	3 81	29.03	0.09	None
Spring †... ..	25.00	75.00	35.00	20.00	18.00		

* Total percentages do not equal 100 in all cases Data given as originally published.

† Percentage of spring months based on field observations plus analysis of a few partridge crops.

Water and Grit. Water in the free state is not an essential element of the habitat (19). Partridges drink at water holes on occasion during periods of drought but appear able to satisfy their requirements with dew and succulent herbaceous materials.

Grit in the crop and gizzard is usually present in large quantities. In one lot of 80 stomachs reported by Kelso (11) the gravel content was 28 per cent of the total stomach contents. The average number of grits in each was 152. In another group of 96 stomachs the proportion of grits was 40 per cent of the total stomach contents. The average reported by Middleton and Chitty (18) in England was 24 per cent. Consumption of grit is greatest when the diet is composed mostly of grains and seeds. In its grit requirements the Hungarian partridge far exceeds any other American gallinaceous bird so far studied.

Population Density. There is not much information concerning population densities beyond the fact that they may become considerably higher than among most other game birds. In England they vary in cyclical fashion (14), the period of abundance or scarcity occurring every 5 or 6 years (16). The degree of stocking that should be regarded as a saturation point has not been determined. For bobwhite, which are similar in many respects, the generally accepted maximum population density capable of being maintained is one bird per acre. Among Hungarians a density of one

bird per acre is probably exceeded in the prairie provinces of Canada, but in the United States it is doubtful if such productivity ever has been attained or will be in the future. When a small party of hunters flushes 1,000 birds in one day, as has happened in Saskatchewan (6), the population is indeed dense. This is not an average day's flush by any means, but it illustrates partridge productivity under ideal conditions. Possibly these high populations are not typical of the general density of Hungarian populations over wide areas even on the Canadian range. Middleton (15) reported that the average fall population on 34,600 acres of English estates was one bird for each 2.0 acres in 1934. On individual estates, the acreage supporting one bird ranged from 0.60 to 3.0 acres. Yeatter's (19) estimate of March populations on three study areas in southern Michigan were 4.4, 11.0, and 13.3 acres per bird; on the better portions of a game refuge in North Dakota, acres per bird ranged from 3.5 to 5.3 (8).

MORTALITY

Mortality before Hatching. The records of nest losses for Hungarian partridges in the United States indicate these losses are relatively high. Yeatter (19) studied 143 nests in Michigan over a 3-year period, and Yocom (20) studied 68 nests in Washington during a 2-year period. The percentages of nest losses compare so closely as to appear almost coincidental (68 per cent loss for Michigan and 67.5 per cent for Washington). A comparison of the nest losses in the two localities is given below.

TABLE 12. NEST FAILURES OF HUNGARIAN PARTRIDGES IN MICHIGAN AND WASHINGTON (IN PER CENT)

Cause	So. Michigan, 143 nests, Yeatter (19)	Washington, 68 nests Yocom (20)
Farming operations	46	84.7
Plowing	..	10.7
Mowing	.	71.8
Farm animals	5	2.2
Predators	26	2.2
Burning	..	2.2
Disturbed and deserted	16	6.5
Hatching failures	3	....
Unknown	4	4.4

The Washington study shows a higher loss of nests in farming operations, particularly during the mowing of alfalfa hay, than did the Michigan study. This was probably because of the higher acreage of alfalfa in the former location. Nest losses caused by wild predators appear much higher in Michigan than on the West coast. This may not mean an actual higher

loss from this cause but rather the difficulty of finding destroyed nests in the fence rows of the Palouse region. In Washington (20) the known predators of Hungarian nests include magpies, skunks, opossum, Columbian ground squirrels, weasels, and house cats. Predation was highest among nests located outside fields along fence rows and roadsides, which served apparently as natural routes of travel for the predators. High nesting mortality is also reported by Hawkins (9) in Wisconsin; 60 per cent failed in hayfields, 55 per cent near roadsides, 25 per cent on all other locations. Mortality in England appears to be lower than in the United States, doubtless because greater care is taken to save nests on agricultural land. The usual nesting loss in England according to Middleton (16) is about 22 per cent. Some of the birds whose first nests are broken up lay a second clutch, usually smaller and less fertile than the first. According to Yocom (20) fertility in general is high, nearly 99 per cent.

Losses Due to the Elements, Predation, and Miscellaneous Causes. Not much is known concerning losses among either juvenile or adult birds; and until this subject has been studied more thoroughly, few conclusions can be drawn. Yocom (20) reports a loss of 47 per cent of the young from various causes during the first 2 weeks of life. Losses of various kinds are reported as found under Michigan conditions. Yeatter's data are shown in Table 13, but because of the high percentage of unknown causes the significance of other items must be regarded with reservations.

TABLE 13. CAUSES OF MORTALITY AMONG HUNGARIAN PARTRIDGES IN MICHIGAN (19)

Causes	No. of cases	Per cent of total
Predators	8	13
Farm machinery	7	11
Flight accidents	7	11
Clay balling	5	8
Disease	4	7
Unknown	30	50

Known cases of predation were limited mainly to the depredations of house cats upon incubating females, a matter already referred to. Of the hawks, Yeatter states the Cooper's hawk is probably somewhat destructive but other species only occasionally so. The status of owls is not clear from Yeatter's observations, but Hammond (8) considers the snowy owl together with the prairie falcon and golden eagle as causes of winter mortality in North Dakota. Flight accidents listed by Yeatter were concerned mostly with collisions against telephone wires along highways. There was no evidence that partridges were run into by automobiles in Michigan, but Hammond found this a primary cause of mortality during winter in

North Dakota, where birds came to plowed roads for grit, accounting for roughly one bird per covey each year. Yocom (20) lists the coyote, house cat, horned owl, Cooper's hawk, marsh hawk, and prairie falcon as predators of the Hungarian under western conditions.

The item listed in Table 13 as clay balling is an unusual type of mortality peculiar to young birds only. Chicks that frequent heavy, fine-textured soils during rainy weather sometimes accumulate clods of clay on their feet, and this so incapacitates the young birds that in time they die from exhaustion, starvation, or some other cause. Clay balling occurs on Hungarian partridges in England also and is said to make their propagation in localities of heavy soil nearly impossible.

Even on the open wind-swept prairie the Hungarian is able to find protection from the wind and low temperatures in the meager cover that exists there. Naturally, it suffers in extreme weather, and doubtless there is a certain amount of winter mortality due directly to the effects of cold, snow, and wind, but loss of this nature is probably less extensive than the casual observer might presume to be the case in view of the uncongenial winter climate that prevails where these birds are most abundant.

Hammond's (8) census records in North Dakota suggest that mortality from the time of brood emergence through February of the following year is about 3 to 4 birds per covey, the average covey containing 12 to 13 birds at the start. This loss included hunting take and all natural decimation. Winter mortality was slightly more than 2 birds per covey, a 20 per cent reduction approximately. Winter losses in England appear to

TABLE 14. LIFE EQUATION OF HUNGARIAN PARTRIDGE AND RECORD OF HUNTING TAKE ON FIVE ESTATES IN ENGLAND (15)

Estate	Acres	No. of nests	August population	Hunting take	Take per acre	Per cent killed	No. left	Winter mortality	Per cent lost
Year 1933									
1	1,100	40	455	155	0.14	34	300	196	65
2	11,000	650	3,930	1,768	0.16	45	2,162	262	12
3	1,400	. . .	712	145	0.10	20	567	267	47
4	5,000	471	4,522	1,786	0.35	39	2,736	1,686	62
5	2,000	100	1,187	321	0.16	27	866	616	71
Year 1934									
1	1,100	52	510	240	0.22	47	270		
2	11,000	950	4,800	2,398	0.22	51	2,402		
3	1,400	150	1,129	704	0.50	62	425		
4	5,000	525	5,100	2,964	0.59	58	2,136		
5	2,000	125	884	392	0.20	44	492		

be heavy (Table 14), for what reason Middleton does not report. There is no evidence that such losses are incurred on this continent.

Lack of marked success with Hungarian partridges in the central part of the United States results apparently from poor reproduction rather than loss of birds after they are produced. McCabe and Hawkins (13) show an average summer gain of 73 per cent for partridges as against 180 per cent for quail in the same area (4).

Losses Due to Hunting. Records of hunting take in America and its effect upon the maintenance of a given partridge population are too meager to be of value. In England the life equation of this bird is pretty well understood, and under conditions there an annual kill that takes 40 to 50 per cent of the fall population appears not to be excessive. Whether or not a hunting take of this intensity can be borne by birds on this continent is not known, probably not, considering the heavy nesting mortality. Hunting take in England varies with the population cycle. During peak years the kill on good range approaches one bird to 1.5 acres; at the base of the cycle the relationship may recede to no more than one bird to 25 acres (16).

In the United States and Canada the status of partridge hunting varies greatly in different localities. Many states permit no hunting even where the bird occurs. In several others the season is short and the bag limit small, usually five birds or less per season. In Washington the hunting kill was one bird killed for each 39 to 50 acres during two seasons (20). The best acre-kill record in Wisconsin was during 1938 in Racine County, where the average kill was 54 acres per bird (13). In Alberta a limit of 15 birds daily and 200 per season has had no ill effects upon a population that is still extending its range and increasing its numbers (6).

MANAGEMENT

Census. The complete census with or without a trained bird dog may be used successfully to conduct population counts of the Hungarian partridge. This method is discussed in detail in Chap. IV, *Pheasants*. Where the census unit is large, the complete-census technique can be applied to sample areas and the data used as the basis for computing the population on the entire unit. This procedure has been adopted in England (15). Middleton's counts recorded the number of birds in each covey and listed the birds as old and juveniles.

Hammond (8) based his estimates of winter populations on an enumeration of coveys that came to highways cleared of snow to secure grit. In a region of heavy snowfall this method has merit, for roads, railroad beds, and similar locations are often the only sites where grit is available.

Food and Cover Development. The Hungarian partridge is so recent an addition to North American fauna that little has been done in the way of

intensive management. However, certain practices can be recommended in the light of what we already know of its life history and ecology.

1. Provide for a supplementary winter food supply. Food supplies can be augmented by reserving an area of standing or shocked corn situated near protective natural cover such as brushy fence rows or kettle holes. Standing corn is more desirable than shocked corn. Shocked oats, wheat, or barley also may be used for this purpose but lose some of their effectiveness in deep snow. The establishment of food patches in orchards has been recommended in Michigan (19). Any of several plant materials may be planted (See Chap. I, *Wildlife Management on the Farm*). Kaffir, sorghum, and field corn all are good food and cover plants. Spreading animal manure on fields during the winter sometimes provides grain at a season when other materials are scarce. Grit, so essential to these birds, can be provided by placing gravel in protected feeding boxes or in piles (8) so exposed that wind keeps them free of snow.

2. Develop coverts of native vegetative species on uncultivated parts of the farm. Efforts to develop cover very often will do more to improve habitat conditions than any other management practice. Range occupied by partridges is often deficient in this vital essential, especially in otherwise suitable nesting sites. Fence rows, roadsides, ditches, railroad embankments, stream banks, rough untillable land, and similar locations if converted to low-growing vegetation of native plants usually provide satisfactory cover. Planting may be necessary in some cases, but not often. Hammond recommends the following species for planting: chokecherry, wild plum, Russian olive, and silverberry. Ordinarily, suitable plant species become established naturally if no attempt is made to eradicate them or if they are protected from grazing animals. Coverts of this nature afford some protection against winter storms and a means of escape from enemies. Yeatter doubts the value of shrubby growth as nesting cover, stating the birds prefer grassland for nesting in Michigan.[1] If no more than a small proportion of all nests are located in hay- and grainfields, cover conditions may be judged adequate. But if fields are used consistently for this activity, preferred cover is presumably not sufficient.

Coverts should be well dispersed and if continuous over long stretches such as along a fence encourage travel to places that otherwise might be avoided. Travel lanes of this character are especially important in winter when birds must forage in wind-swept fields, which provide little natural protection in themselves. Preferably, cover should be shrubby in nature, but tall grass and other herbaceous growth if left undisturbed are superior to mowed fields and grain stubble. Woodland cover appears to be unsuited to use by Hungarian partridges.

[1] Statement by correspondence

3. Protect nesting birds. The ideal procedure in avoiding needless injury and death among incubating birds is to provide cover of a type that will draw them away from the fields where they are likely to be harmed by farming operations. Where fields are used intensively, partridge losses may possibly be reduced by equipping mowing machinery with a flushing bar. This device is described and illustrated in Chap. I, *Wildlife Management on the Farm.* However, it is not very effective on rapidly moving tractor mowers. In England the usual procedure is to seek out nests and mark their location in advance of mowing operations. This is an ideal method but possibly too expensive for conditions as found in North America. Use of the flushing bar is less expensive. Since nests tend to be more numerous in the marginal 20 to 30 feet of a field, this strip might be reserved for late mowing where feasible or examined carefully before early mowing begins. Burning and clearing along highways and railroad rights of way should be delayed until the nesting season has passed, or if necessary burned before mid-April. Elimination of house cats will reduce some of the predatory destruction of nesting birds.

4. Control hunting. No hunting should be allowed in states, provinces, or parts of them where partridge populations are not yet well established and thriving. Once begun, hunting must be regulated conservatively until its effect is thoroughly understood.

5. Establish refuges. This practice is desirable in states that permit hunting. Otherwise areas of low population may become barren. In other states the whole state becomes a refuge if hunting is not legal.

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CHAPTER IV

PHEASANTS

(*Phasianus colchicus torquatus, P. colchicus mongolicus, P. versicolor, P. colchicus colchicus*)

GEOGRAPHICAL DISTRIBUTION

The ring-necked variety of pheasant is a large and striking bird, especially the male with its long sweeping tail, red-brown breast feathers, and bright red head wattles. The female is of a more uniform light brown color and therefore less conspicuous. The white ring around the neck of the male occurs in only the Chinese and the Mongolian varieties.

The original home of the pheasant is frequently given as northern China, Korea, and parts of Siberia; Gaillard (24), however, indicates that the fossil bones of this bird have been found in Miocene deposits in France. Several subspecies occur over a wide range in southern and eastern Asia from the Black Sea to eastern China (3).

In North America, the pheasant occurs in greatest abundance throughout the northern part of the United States and southern Canada (22, 61). The bird is most plentiful in the fertile river valleys and bottom lands of the Northern states, while southward and in the areas of higher elevation it is less numerous (*41 g.r.*, 32).

Four principal species and subspecies of pheasants are now found in North America: the Chinese ring-necked pheasant, *Phasianus colchicus torquatus;* the Mongolian pheasant, *P. c. mongolicus;* the English pheasant, *P. c. colchicus;* and the Japanese pheasant, *P. versicolor*. The first named is the most abundant, but crossbreeding is common, and wild stock is frequently a combination of many types.

LIFE HISTORY AND ECOLOGY

Breeding Characteristics. Pheasants are polygamous, one male usually mating with several females. One game farm in Massachusetts reports a case where eggs of high fertility were obtained from 19 females confined with one male.[1] Ordinarily, however, a harem in the wild state consists of two to eight hens (10). Occasionally a male appears to be monogamous (3, 41).

Mating begins in late winter or early spring. The cock selects a mating site, known as a crowing area, which he defends against other males. To

[1] Reported by Carl Boyce at the Ayer State Game Farm, Ayer, Mass.

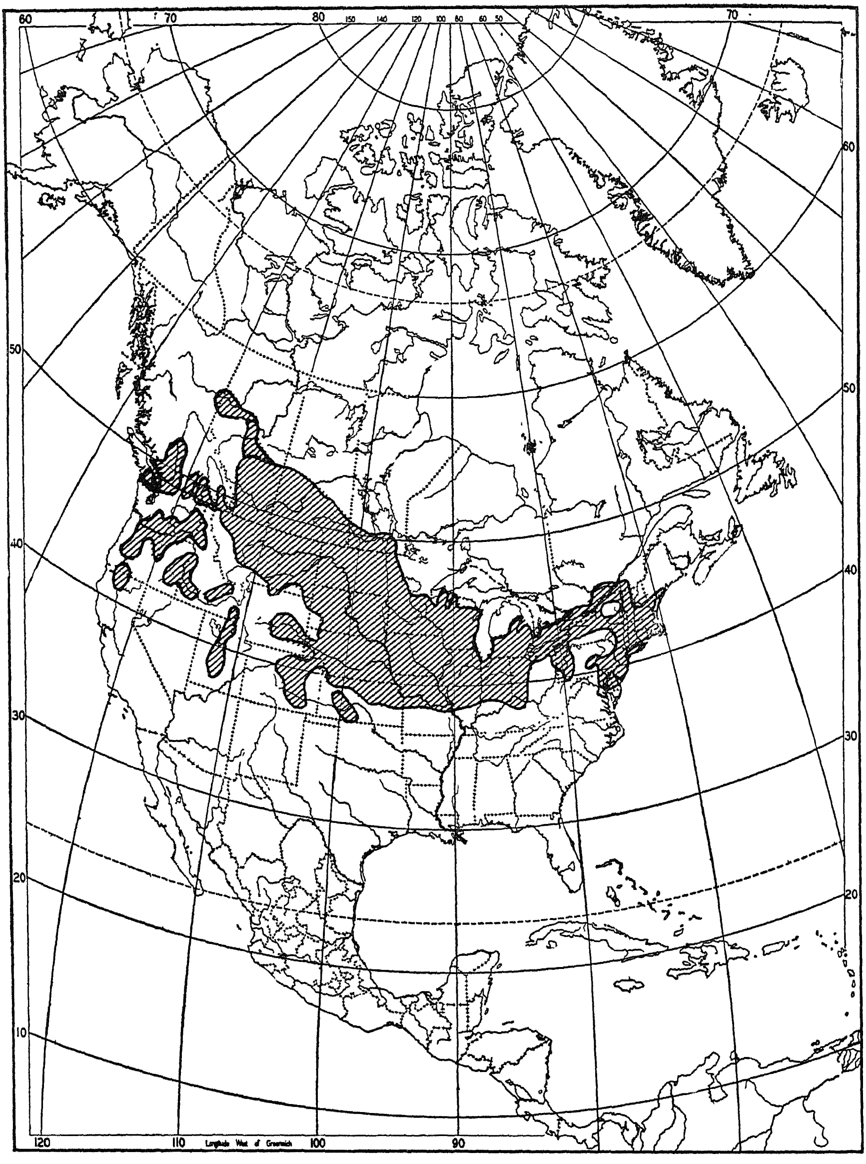

FIG. 4·1. Range of the ring-necked pheasant. (*U.S. range by U.S. Fish and Wildlife Service, 1943. Canadian range by C. H. D. Clarke, Toronto, Canada, 1947.*)

this area he attempts to attract the hens by crowing and flapping his wings. Most of this activity takes place in the early morning, but also to a lesser extent in the early evening. Attracting the females is essential, because during the winter months prior to the breeding season the two sexes seldom

mingle, each traveling in small flocks of their own sex. When a female comes within the crowing area, she is courted royally, but not exclusively, for females may visit more than one crowing territory.

Nesting is carried on from May to September but the incubating period is largely completed by July. Nests are generally located near the crowing area in suitable cover, the choice depending primarily upon what is available.

TABLE 15. SUMMARY OF THREE STUDIES ON THE NESTING SEASON AND NUMBER OF EGGS IN CLUTCHES

Item	Ohio, Strode and Leedy (53)	Iowa, Hamerstrom (31)	Pennsylvania, Randall (51)
Start of first nest......	May 3	1933 — Apr. 25 1934 — before Apr. 13 1935 — Apr. 4	Early April
Start of last nest......	Sept. 16	1933 — about July 1 1934 — Sept. 4 1935 — July 21	Late August
Average clutch........	8.8 eggs	1933 — 12.3 eggs 1934 — 10.1 eggs 1935 — 12.4 eggs	10.8 eggs
Range in size of the clutches............	....	1933 — 8–17 eggs 1934 — 4–20 eggs 1935 — 8–26 eggs	4–24 eggs

The nest is made on the ground in a slight depression lined with grass or other available materials. Its exact location seems to be but little influenced by exposure or the proximity of trees (31). Drainage ordinarily is satisfactory but not always.

The average clutch contains 11 eggs, but the number may vary from 8 to 13 or higher. Occasionally, when proper nesting cover is scarce, two hens may use the same nest, accounting, perhaps, for the large clutches sometimes reported. Only the female participates in the incubation activities, which last 23 to 25 days. During this period the hen rests from her duties at dawn and late afternoon (58).

Fertility among successfully hatched clutches may be 90 per cent or better (17, 28, 31, 51, 53). Not all chicks are able to work their way out of the egg, while others may die before the brood leaves the nest. Randall (51) found the average brood in Pennsylvania to be 9.7 chicks at the time of hatching. After 10 weeks this number had been reduced to 8.5. Hicks (36) reported the average size of 278 broods in Ohio as 7, ranging from 6 to 12.

As soon as the pheasant chicks are hatched, the mother leads them away from the nest and attends them with great care until they are able

to fare for themselves. During normal activities the brood is spread out fanwise with the mother in the rear. If danger approaches, she immediately feigns injury in an attempt to lead the intruder toward herself and away from her brood. The chicks, in the meantime, take shelter under leaves and other materials, where they are almost perfectly concealed, so well does their color blend with their surroundings. After 6 to 8 weeks the brood begins to disperse but never far, rarely straying any great distance from the original nesting site (*41 g.r.*, *86 g.r.*).

Movement. *Daily movements* depend to a large extent upon the proximity of suitable cover and an adequate supply of food. The typical daily routine consists of travel from the roosting area to the feeding grounds in the early morning, feeding and resting during the day, and the return journey in the evening. The birds feed actively during the early morning and late afternoon, resting for several hours in the middle of the day. When the feeding grounds are close to the roosting area, travel is reduced to a minimum; when food is scarce, travel farther afield is necessary.

Seasonal movements are contingent upon several factors. During the mating season and the molting period that follows, the male birds restrict their activity to areas of dense cover. At other times, they resume the normal routine. The female is least active during the nesting and rearing periods, gradually extending the range of her movements as the young chicks grow older and gain strength.

With the approach of winter the two sexes largely separate into bands varying from a few birds to more than 200 in some instances. The largest band observed by McCormick (46) in Ohio contained 362; other bands ranged from 80 to 250. Each band usually contains birds of one sex. In Massachusetts these bands, ranging in size from three to eight, begin to form in December (55). This mode of existence is maintained until late winter or the spring mating season. The males disband in February to select crowing areas; the females disband in March. In southeastern Minnesota single males were found more frequently than single females, and these males traveled farther from suitable food and cover than did the females (48).

Normal daily and seasonal activity may be disrupted at any time by a number of contingencies, the principal one being the movements of other animals that inhabit the same range or intrude upon it. Man and his dogs are constant disturbing factors, especially during the hunting season. The harvesting of crops, such as the husking of corn, destroys a feeding ground in one location, while the spreading of barnyard manure creates a new food source at another location. Deep snow may render useless an accustomed roosting site. These and other similar circumstances constitute periodic interruptions that influence the activities and movement of pheasant.

Leopold, Lee, and Anderson (42) found that native pheasants in Wis-

consin migrate from the sparsely covered uplands to the river bottoms but that newly released pheasants remain on the upland situations if provided with food supplied in feeders and with artificial cover in the form of brush piles and other shelter. Apparently, pheasants do not move from uplands to lowlands if food and cover are satisfactory in the former.

In this same study pheasants were released under a variety of conditions for the purpose of observing their subsequent behavior and movements. Only 2 birds in a release of 43 returned to their home range, a return trip of 1 mile. Eleven birds all dispersed when released where both food and cover conditions were poor. When 32 birds were released where food was good but cover only fair or unsatisfactory, some dispersed while others remained. None of the 29 released in an area having good cover and food were observed to disperse farther than a near-by feeder. In a study of released banded pheasant cocks in Massachusetts, Wandell (57) reported that 67.5 per cent moved less than a mile although a few birds moved as far as 25 to 30 miles. Buss (10) reports that wild pheasant in Wisconsin generally move less than ¼ mile but released birds may move as far as 7 miles.

In New Hampshire following their release in 1938, birds were reported to have traveled slightly more than ½ mile from the point of liberation and as far as 5 miles following their release in 1939 (27, 28). Green (30) tells of pheasants in northern Iowa traveling from ⅛ to ¼ mile daily between their roosting and feeding grounds. Leopold (*66 g.r.*) gives the average daily cruising radius as ⅛ to ½ mile, the maximum as 2 to 3 miles, and the average seasonal radius as ½ to 1 mile.

Cover. Pheasants need cover for a variety of uses, such as roosting, nesting, feeding, escape from their enemies, and rearing their young. Cover for each of these needs will vary on different parts of the range as well as in relation to the availability of food, the intensity of severe weather, and the number of enemies. Wight (60) lists the following cover requirements: roosting sites for each season, wood lots and other special roosting sites, crowing areas, nesting cover, escape cover, and lanes of travel among the various parts of the range.

Winter-roosting Cover. During the winter pheasants prefer to roost in dense low cover. In Iowa, Green (30) found pheasants roosting on the ground in the following cover types: deciduous groves, willow sloughs, unmown sweet clover, and fields of unharvested sweet corn. Possibly the last type was tolerated because it afforded an excellent supply of food. In the glaciated areas from Massachusetts west to Michigan, kettle holes, swamps, and marshes are favorite winter-roosting sites, where the birds sit on or near the ground. The vegetation on these sites may vary in composition from low herbaceous plants to a mixture of deciduous-coniferous trees and a thick undergrowth of both woody and herbaceous plants. Sedge and

cattail swamps are favorite roost sites in the eastern part of the United States (45). Locally in Pennsylvania and Ohio, birds are known to roost in young conifers.

Leedy (39) believes the wood lot to be one of the more important types of pheasant cover at any season, especially in winter. As proof of this contention he found that 37 per cent of all pheasants seen in the winter were encountered in woodland cover. More than 600 pheasants were observed roosting in one wood lot during this season, and of this number 85 per cent were roosting in trees and the remainder on the ground. Swamp white and pin oaks seemed to be the favorite roosting trees. Heavy pasturing of wood lots depletes the best pheasant cover, but an ungrazed condition appears to be less desirable than one moderately grazed. According to Leedy, the ideal condition in a wood lot is an understory of briers, panicled dogwood, hawthorn, and prickly ash, particularly along the borders and scattered in patches through the woodland.

Apparently the choice of winter-roosting cover for pheasants varies with the locality and the vegetation available for protection. The following table is given as an indication of the choice of cover by pheasants during severe January weather in Pennsylvania (49):

TABLE 16. ROOSTING COVER USED IN WINTER BY PHEASANTS IN PENNSYLVANIA (49)

Type of cover	No. of birds	Per cent of total
Thickets along streams	82	29
Brushy mine pits and wastelands	67	24
Hedgerows	44	16
Standing corn	40	14
Stubble fields	19	7
Coniferous plantations	17	6
Orchards	11	4
Total	280	100

Wood County, Ohio, is one of the best pheasant-producing areas in the Eastern United States, and its winter cover apparently approaches the ideal. Six per cent of the land of this county consists of woodland, and Leedy (39) states that there is, on the average, one 12-acre wood lot for every two sections of 640 acres each. This gives a satisfactory amount of cover. This investigator indicates that if wood lots with suitable ground cover are closely spaced, the carrying capacity of the area for pheasants is increased. For Wisconsin Buss (10) concludes that winter cover too widely dispersed prevents the summer range from working to capacity.

Crowing and Nesting Cover. Cock pheasants establish their crowing territories from late winter to midsummer, and it is near these areas that

the hens make their nests. Crowing-territory cover and nesting cover are, then, closely related and may be one and the same. Crowing territories consist of cover in which the male can hide and where food is adequate, but no investigator seems to have determined just what constitutes ideal crowing-cover conditions. Moreover, little is known of size limitations of crowing territories. Wandell (56) states that the size of the crowing territories in the Connecticut River Valley in Massachusetts varies between 20 and 70 acres. Along the lower Merrimack River in New Hampshire Gould (28) found the average crowing territory to be approximately 44 acres, with seven types of cover present in this locality including hay land, 48 per cent; herbaceous cover, 17 per cent; cultivated land, 15 per cent; hardwood woodland, 13 per cent; brush, 7 per cent; pines, trace; and alders, trace.

A crowing territory is nothing more than good winter-roosting cover in units sufficiently small for each individual male to have an area of his own reasonably situated with respect to feeding ground. Cover to approach perfection should contain escape cover, such as fence rows, woodland borders, swamp and marsh borders, kettle holes, and miscellaneous grass, weed, and brush mixtures. In addition, there must be suitable and safe nesting cover for the hens when they occupy area adjacent to the crowing territory. Pheasants will nest in almost any vegetation that is tall and dense enough to cover the nest and its occupant. Hayfields, fence rows, hedgerows, grain crops, and orchards all provide attractive nesting cover but not all provide safe cover. Nesting cover has been studied quite thoroughly in a number of localities; a summary of four investigations is given below.

TABLE 17. SUMMARY OF STUDIES OF NESTING COVER IN FOUR DIFFERENT STATES

Type of cover	Per cent of total nests			
	Ohio (53)	Michigan (17)	Iowa (31)	Pennsylvania (51)
Hayland	64	62	26	59
Small grains	10	5	4	12
Fence rows	7	9	8	5
Roadsides, etc.	6	1	22	7
Woodland and plantations	6	6	3	2
Sloughs and marshes	Not listed	5	21	Not listed
Wasteland	Not listed	0	3	12
Miscellaneous	7	12	13	3
No. of nests	563	138	445	310

Table 17 must not be interpreted too literally, for the various cover types differ greatly in different places. In the region of Pennsylvania

studied, Randall found that the preponderance of nests in hayfields occurred there because the area of such land far exceeded that of any other type. On the basis of equal areas his studies showed the following order of preference: roadsides, 100; fence rows, 94; coniferous plantations, 27; wasteland, 25; alfalfa and clover, 22; pasture, 8; wheatland, 3; other small grains and potatoes, 1. These data indicate a decided preference for cover of a shrubby or wooded character. The importance of hayfields as nesting cover cannot be overlooked, but it is possible that wherever shrubby cover types occur near a crowing area, this condition tends to be more favorable for successful incubation, since the denser cover may attract the females away from hay and croplands where many nests are destroyed by harvest operations.

Summer- and Fall-roosting Cover. The summer period is one of peace and plenty for the pheasant, relatively speaking. Food and cover are abundant. At this season pheasants desert the brush swamps and wooded areas where they have roosted during the winter for more open land like hayfields and herbaceous marshes. All types of crops are growing rapidly at this time, and the lush growth furnishes both food and cover. Both hay- and grainfields prove hazardous ground as the season advances, for mowing operations destroy cover and occasionally injure or kill birds, although this type of loss is not likely to be an important factor among the males or nonnesting females.

Early fall roosting cover is little or no different from the summer cover. Frosts may reduce cover along fence rows and in waste places, but the amount and variety are usually adequate. Late in the fall, the birds move back to the swamps and marshes in preparation for the winter.

Escape cover is vital to pheasants as a place of escape both from predatory animals and from man during the hunting season. A cover of dense shrubs may give protection from enemies like the great horned owl or the Cooper's hawk, while rivers, swamps, and marshy land may provide sanctuary from man and bird dogs during the hunting season.

Where cover and food supplies are near each other, cover lanes are unnecessary. In parts of the Middle Western states, where cover is widely separated by open cultivated land, the need of cover lanes is more necessary.

Food. Although the food of the pheasant is a subject that has received intensive study, the data secured to date are inconclusive due to several difficulties centering chiefly around the variation in food habits and food. One problem involves the differences in feeding habits that are to be expected because of the diversity of materials available in different localities. A second difficulty involves the securing of source material for all months of the year in all parts of the range.

The food of young pheasants differs from that of adults. Young birds,

growing rapidly, need a food high in protein, much of which is derived from a diet of insects (see Fig. 4·2).

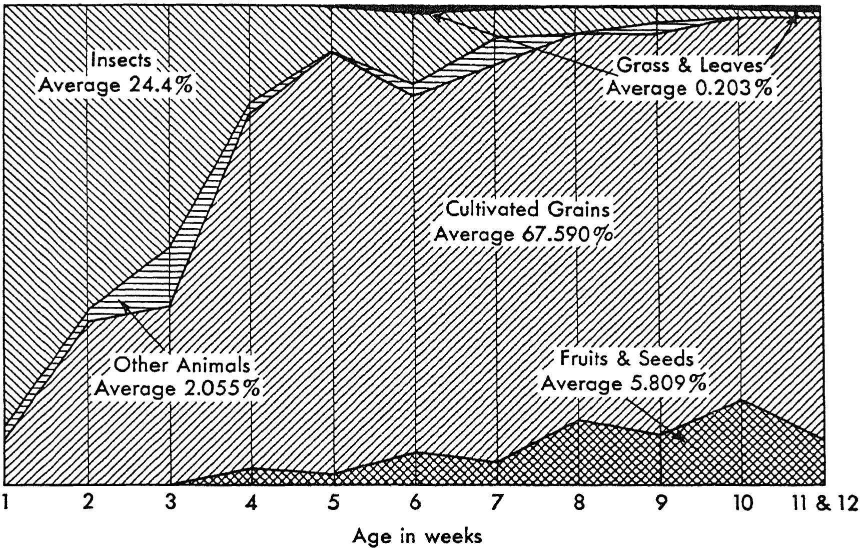

FIG. 4·2. Food of young pheasants. Graph shows the relative quantities of different classes of food for young pheasants up to 12 weeks old. Note the decrease of insects and the increase of cultivated grains as the birds approach maturity. (13)

The following table was compiled from data collected in southern Michigan (13).

TABLE 18. THE FOOD OF JUVENILE PHEASANTS AS SHOWN BY THE ANALYSIS OF STOMACHS COLLECTED IN MICHIGAN (13)

Foods	Age, weeks										
	1	2	3	4	5	6	7	8	9	10	11 and 12
	Per cent of total										
Insects.........	87.3	63.2	50.6	19.8	7.4	16.8	6.3	6.1	4.1	1.4	2.1
Other animals...	2.7	1.4	12.3	0.2	0.7	1.4	4.8	0.0	1.0	0.6	0.1
Cultivated grains	10.0	35.3	37.1	78.9	90.8	74.2	84.4	79.6	84.7	79.1	89.3
Wild fruits.....	0.0	0.0	0.0	1.1	0.0	7.1	0.0	0.5	2.2	0.3	0.1
Seeds..........	0.0	0.1	0.0	0.0	0.5	0.2	4.5	13.7	7.9	18.3	7.4
Grass and leaves.	0.0	0.0	0.6	0.0	0.6	0.3	0.0	0.1	0.1	0.3	1.0

It seems apparent that the need for insect (high-protein) food declines as the age of the chick increases, because more insects are available as the season advances but fewer are eaten. Dalke (11) found the insect popula-

tion to be greatest in September, when the weight of air-dry insects reached a high of 5.75 pounds per acre. Possibly the smaller proportion of insects taken as the chick becomes older reflects no change in nutrient requirements but means only that a pheasant of that age is able to obtain its protein from vegetable sources.

The Food of Adult Pheasants. Johnson (37) reports that in South Dakota pheasants ate 100 different species of insects, seeds of domestic grains, and wild plants. "The seeds taken in the largest quantity were

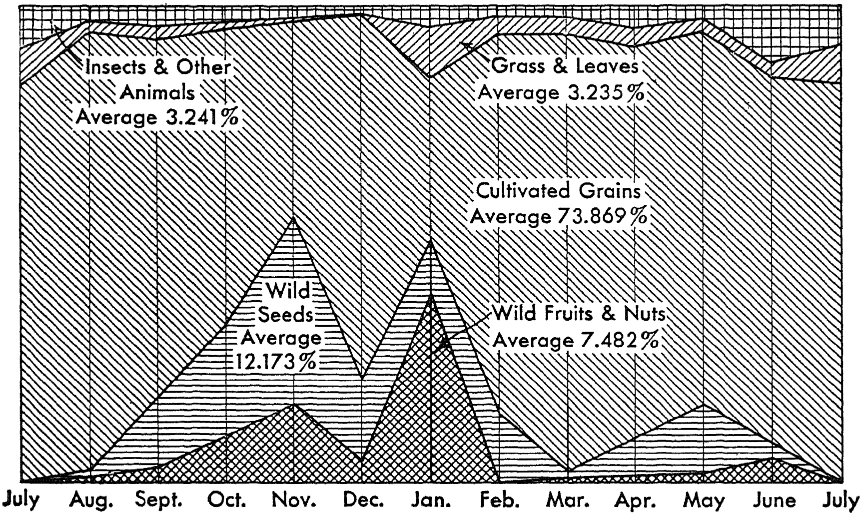

FIG. 4·3. Seasonal foods of adult pheasants. Note the preponderance of cultivated grains. Insects reach their highest degree of importance in June and July, and wild seeds, in early winter and early summer. (11, 12)

green smartweed, wild buckwheat, giant and little ragweed, bindweed, smartweed, wild sunflower, wild rose, wolfberry, Russian thistle, wild oats, corn, wheat, oats, and barley."

Hicks (33) states that the food of pheasants examined in Ohio contained 91 per cent plant materials and 9 per cent animal matter. He lists 62 species of plants and 39 species of animals. The seven most important plant materials in the order of their importance were corn, common ragweed, wheat, foxtail, smartweed (three species), common oats, and black bindweed.

Dalke (11, 12), working in southern Michigan, where he examined 352 adult and 138 young pheasants collected during various months of the year, found that corn was the most important of the cultivated grains, followed in order by wheat, barley, beans, oats, and buckwheat. Of the weed seeds, the order of preference was common ragweed, hog peanut, yellow foxtail, skunk cabbage, green foxtail, and black bindweed (see Fig. 4·3).

Each adult bird ate on the average 55 grams of food per day. A square mile of typical agricultural land, which he found to contain 6,303 pounds of waste grain and weed seeds, if available would be capable of sustaining 242 pheasants from Sept. 1 to Apr. 1.

Examination of 515 pheasant crops in Minnesota showed an average content of 81 per cent cultivated grains, 6 per cent weed seeds, 4 per cent fruits, 4 per cent animal matter, and 5 per cent miscellaneous materials (23). Corn constituted one-half of the cultivated grains.

In Pennsylvania Bennett and English (4) indicate the five most important fall foods to be as follows:

	Per Cent of Total Volume
Corn	54
Common ragweed	5
Grasshoppers	5
Buckwheat	3
Skunk cabbage	2
All others	31
Total	100

The annual food of adult pheasants in Massachusetts consists of wild seeds, 32 per cent; domestic grains, 26 per cent; insects, 20 per cent; vegetative materials other than seed, 12 per cent; and fleshy fruits, 10 per cent. As in other regions, corn is the most important of the domestic grains and skunk cabbage is the leading item of the wild seeds in the fall, particularly during the hunting season. Fruits, especially apples, are eaten most extensively in winter, no doubt because of the availability of windfalls during open winters. Wild fruits are also eaten consistently (47).

In general, the literature shows that cultivated grains, particularly corn, are of high importance on the pheasant range. In the plains region of Nebraska the sunflower family (*Compositae*) replaces cultivated grains to a marked degree. In the Northwest greens and wild fruits are of major importance as food for pheasants (44). Of the weed seeds, ragweed, and green and yellow foxtail are favorites.

Water. Dalke (11) states that pheasants fare as well where they have no access to water as where it is available. He indicates these birds are able to satisfy their water requirements from dew when more suitable sources are lacking. No doubt they also obtain part of their supply from grains, juicy fruits, and the leaves of succulent plants.

Grit. Grit is not a food, but in seed-eating birds it is so closely associated with the process of nutrition that it will be considered here in the sense of a food requirement. Dalke (14) found that the grit content of young pheasant gizzards increased from 0.43 gram in birds 1 week old to a maximum of 3.08 grams in birds 10 weeks old. For adult birds the amount

of grit ranged from a high of 5.50 grams in April to a low of 2.20 grams in December, the average weight being 3.39 grams for the year. The most common materials were quartz, granite, and schist. A knobby grit of impure quartz about 3/16 inches in diameter has been recommended by an English investigator as being best suited for pheasants.

Population Densities. The density of pheasant populations varies greatly in different parts of the pheasant range. These variations are both regional and local. Westward in the United States regional concentrations are found in Pennsylvania, Ohio, Iowa, South Dakota, and Oregon, and locally in southern Canada.

Summary data in Table 19 indicate ranges of moderate to high productivity throughout most of the pheasant territory of the United States.

TABLE 19. RANGE DENSITIES FOR PHEASANTS

State and author	Year	Study area, acres	Acres per bird	
			Spring	Fall
New Hampshire:				
Gould (27)........	1938	800	53.3	
Gould (28)..........	1939	275	....	14.5
Massachusetts:				
Wandell (56)...	1940	6,000	98.3	18.2
Pennsylvania:				
Gerstell (25)........	1934	1,400	0.83	0.4
Randall (49)........	1938–1939	850	34.0	2.0
		825	4.5	2.0
Ohio:				
Hicks (36)..........	1938	640	.....	1.9
	1938	640	.....	2.8
	1938	640	.....	4.0
Michigan:				
English (17).........	1932	680	7.2	3.9
Burroughs (8).......	1937			2.2
Wisconsin: Leopold (41)........	1936	500	1.7	
	1936	240	3.7	
	1936	1,700	11.3	
	1936	780	13.7	
	1936	200	33.3	
Iowa:				
Green (30)..........	1935–1936	4,900	19.9	4.9
South Dakota:				
Johnson (*66 g.r.*).....	....	640	2.6	
		600	6.0	
Washington:				
Einarsen (15)........	1941	397	.....	0.3

Although the pheasant range in certain states is notable for its high productivity, even these areas display marked differences in population

densities. Recent surveys in Ohio (36) gave the following populations in 13 counties expressed in number of birds per square mile: 342, 230, 160, 143, 133, 65, 62, 59, 41, 39, 38, 14, and 13. The average density was 102, or approximately 6.5 acres per bird. All 13 counties are located in that part of the state where pheasant populations are high. Tubbs (54) says the producing power of good farming lands in the Thumb district of Michigan, which yields about 100 cocks per square mile per year, is three times the total population on less productive lands in southern Michigan.

MORTALITY

Mortality before Hatching. Man, predators, and other forces of nature take a heavy toll of nests in all parts of the pheasant range. Available data indicate that the rate of nest mortality is rarely less than 50 and occasionally more than 80 per cent. The findings of several studies are summarized in Table 20.

TABLE 20. NEST LOSSES ON DIFFERENT PARTS OF THE PHEASANT RANGE

Author	Year	Location	Total No. of nests	No. failed	Per cent failed
Strode and Leedy (53)	1939	Wood County, Ohio	563	234	42
Randall (51)........	1939	Lehigh County, Pa.	310	247	80
English (17)........	1932	Ingham County, Mich.	138	81	59
	1933	Ingham County, Mich.	55	45	82
Hamerstrom (31)....	1933	Ruthven, Ia.	44	29	66
	1934	Ruthven, Ia.	169	125	74
	1935	Ruthven, Ia.	232	188	81
All nests.........	......	....	1,511	949	63

The causes of mortality are many, but those attributable to man and his activities are by far the most important, usually accounting for more than half of the total losses. The mowing of hayfields appears to be the most destructive single cause in all localities. Not only are eggs destroyed, but in addition the incubating female may be killed or crippled. For example, of 100 nests located in hay in 1939 and disturbed by mowing, the female was killed in 11.6 per cent of the cases and crippled in 19.8 per cent, or a total loss of 31 females for each 100 nests (40).

Despite the high nest mortality, one investigation (20) indicates that a surprisingly large proportion of the females, perhaps 70 to 80 per cent in some cases, succeed in raising a brood each season, largely because of their ability to renest a second or third time when previous attempts had been frustrated. This estimate is based upon a hen mortality of 8 to 9 per cent. Where mortality of the female is higher due to mowing losses, as was indi-

TABLE 21. SUMMARY OF STUDIES IN FOUR DIFFERENT STATES REPORTING CAUSES OF NEST FAILURES

Cause of failure	Per cent of losses			
	Ohio (53)	Iowa (31)	Pennsylvania (51)	Michigan (17)
Mowing	54	30	50	53
Predators	18	19	31	6
Livestock	2	8	...	7
Desertion	1	5	7	
Flooding	...	6	2	1
Miscellaneous	21	14	6	21
Unknown	4	18	4	12
Total	100	100	100	100

cated for Ohio (31 per cent), the percentage of success usually would be correspondingly less.

Losses Due to the Elements. Although the pheasant usually is a hardy bird, there are certain weather conditions that affect it unfavorably. Cold, wet weather is responsible for a considerable shrinkage in young broods during the first 6 to 10 weeks (18). Errington and Hamerstrom (20) report a gradual loss from an average brood of 8.7 chicks at the time of hatching to 4.9 chicks 10 weeks later. Losses of similar proportions are recorded by Wandell (55). Gould (27) writes that in southern New Hampshire only 15 out of 79 chicks survived until Sept. 1.

Even well-fed mature birds may succumb during periods of unusually cold and windy weather. Green (30) records a case in Iowa where 28 per cent of the birds under observation were lost during heavy winter storms and cold weather when the air temperature dropped to − 35°F. Many froze to death, others were trapped in the snow, and some appeared to suffocate when ice covered their beaks and nostrils.

Losses Caused by Predatory Birds. Loss of pheasants from predatory birds is not easy to determine, but all available data indicate that certain predators take a greater toll than others. Among the most destructive is the great horned owl, which not only preys upon young birds but is large enough to kill adults as well, particularly when the attacked birds are pen-raised and unfamiliar with the perils of the wild. References to the depredations of this predator are many (17, 21, 27, 55). The Cooper's hawk is another serious enemy and like the great horned owl is capable of killing mature birds. Of the hawks and owls these are the only two recorded in literature as important predators of pheasants.

Among the other birds, Randall (51) found that crows, purple grackles, and blue jays destroy eggs in the nest, accounting for 8 per cent of the nesting losses observed.

Losses Caused by Predatory Mammals. House cats, red and gray foxes, skunks, and weasels are known to destroy both pheasants and their eggs, but the loss by mammalian predators seems not to be a very important factor in mortality. English (17) found a house cat eating a pheasant but states that the bird may have been injured by a mower several days before. A Pennsylvania study on 1,675 acres with a spring breeding population of 204 birds disclosed only one pheasant killed by a house cat (52). In New Hampshire, on the northern edge of the pheasant range, Gould (29) found that in one experimental area the annual loss of adult pheasants from predators was 38 per cent and as high as 50 per cent for the juvenile birds. These losses were due primarily to the work of foxes and house cats, the latter being responsible for 32 per cent of the total. The cat population was one cat for every 40 acres.

Both the red and gray fox will eat pheasants on occasion, but few authors mention these species as being important predators. Errington,[1] in a study of 52 red and gray fox stomachs and 113 fox dens, found the remains of four pheasants in the stomachs and 314 remains around the dens. Of the identifiable latter, 98 were cocks and 201 hens. In an analysis of 1,175 fox fecal samples, pheasant remains were found in 66. In New Hampshire foxes appear to account for more than half of the predatory losses (29). New Hampshire has an estimated fox population of more than four to the square mile, which probably explains the heavy loss from this cause. Predation on pheasants by foxes does not appear to be high in other localities. It is significant, however, that losses due to this carnivore seem to be seasonal, with the heaviest losses occurring in the winter when pheasants are found in flocks and in the spring when the birds, particularly the males, are preoccupied by breeding activities. This condition of seasonal losses has been recorded by Scott [2] in Iowa.

The common skunk is a predator that appears to specialize in destroying eggs in the nest. Randall (51) states that the damage can be attributed more to certain individual skunks that form egg-eating habits than to the skunk population as a whole. It is doubtful if the skunk can be regarded as a very serious predator of the pheasant, except perhaps where this animal is unusually abundant. This fact is borne out by several widely separated studies on the food habits of the skunk.

Weasels destroy eggs and may kill young chicks. It appears unlikely, however, that this animal is ever a serious predator. In Randall's studies (51) it accounted for but 1 per cent of all nesting losses. The author's own experience leads to the belief that a weasel is afraid of a broody

[1] Errington, Paul L. 1935. Food habits of mid-west foxes. *Jour. Mammal.* **16**(3):192–200.

[2] Scott, Thomas G. 1943. Some food coactions of northern plains red foxes. *Ecol. Monogs.* **13**(4):427–479.

pheasant and will not approach the nest while the female is in the vicinity. In the one case observed the weasel when confronted by the hen made a hasty retreat to its den, which was located 6 feet from the nest. An egg placed on the ground at the mouth of the lair was uninjured during the several days it remained there. Work on the winter and spring feeding habits of the weasel in Iowa showed no traces of pheasant remains.[1]

On Protection Island, Washington, Einarsen (15) gives the mortality of pheasants from all causes as slightly more than 9 per cent. No hunting is allowed on the island, and the predators are uncontrolled.

Hunting Losses. The average *hunting take* is difficult to determine, and few reliable data are available on this subject. According to Bishop (6), hunting activities removed 80 per cent of the resident and stocked cocks on an 800-acre tract in Connecticut. Green (30) reports a take of 51 per cent in one study in Iowa, while Wandell (55) reports another of 44 per cent in Massachusetts. These figures suggest that the take in certain areas is considerable.

Additional evidence is furnished by Burroughs (8) and Burroughs and Dayton (9), who give some interesting information concerning hunting conditions in central Michigan. For each square mile of hunting ground, 47 male birds were shot during a 17-day season in 1937, 94 in 1938, and 101 in 1939. During these 3 years the number of hunters for the 8,400-acre area was 8,168, 14,068, and 21,481, respectively. Hunting pressure was heaviest on the first Sunday of the open season, when there was one hunter for every 22 acres in 1937. The records for 1938 and 1939 indicate that there was one hunter for each 10 and 5 acres respectively. In 1937, 75 per cent of the hunters using dogs accounted for 87 per cent of the take.

The hunting pressure on an experimental area at Rose Lake, Michigan, was 245 gun-hours, and 17 cocks were taken per 100 acres (1). Even with this hunting pressure there were 16 cocks and 51 hens left on 800 acres after the season closed.

In Ohio where the hunting season lasts for 15 days and only cock pheasants may be shot legally, for every 100 males shot 17 per cent are adults and 83 per cent are juveniles. For every 100 cocks killed 40 hen pheasants are lost by accident or otherwise. During the hunting season 74 per cent of all cocks and 22.3 per cent of all hens are killed (34). Nearly 47 per cent of all birds are lost (34).

Crippling losses account for many of the birds lost during the open season; these do not appear in the records of the hunting kill. Such losses arise from cripples that eventually die and dead birds not found by the

[1] POLDERBOER, EMMET B., LEE W. KUHN, and GEORGE HENDRICKSON. 1941. Winter and spring habits of weasels in central Iowa. *Jour. Wildlife Mangt.* **5**(1):115–119.

hunters. Data published by Randall (50) show that the loss from this source may be great. His study indicates that 32 per cent of the 631 birds shot at by hunters were lost in this manner. The loss was less where dogs were used. In both cases the more experienced hunters lost fewer birds than the novices. Randall believes, as do many others, that extremely long shots are likely to result in fewer birds in the bag and more cripples left to suffer and die. One study by Errington and Bennett (19) found that veteran hunters lost 19 per cent of their birds; average hunters, 36 per cent; and novices, 39 per cent. English (17) estimated the crippling loss to be as high as 33 per cent. As one would expect, crippling losses are lower on snow-covered ground.

Many states now have a season that allows legal shooting of males only. Hens are frequently shot, however, by overanxious hunters, and most of these are left dead in the fields. The loss of hens in northwestern Ohio amounts to one-fifth of the legal take (40).

Only a beginning has been made to understand the factors that decimate wild animal populations. Even less is known of the quantitative effect of these losses. In Wisconsin Leopold and his associates (43) have measured the life span of the pheasant by trapping, banding, and retrapping over a period of several years under conditions where hunting was not allowed. One hundred pheasants were banded the first year. Live trapping during the succeeding 5 years revealed a survival of 30 birds the second year, 9 the third year, 2 the fourth year, and none the fifth year. These data emphasize two important facts: (1) the high percentage of loss of pheasants not including the decimating effects of hunting, and (2) the extreme importance of the yearly reproduction in holding pheasant populations at a constant level. These conclusions suggest that the loss of broods during one or more seasons may be an important cause of cyclic behavior in animal populations.

MANAGEMENT

Census. The census is one of the most useful techniques available to the game manager who would handle his game on a basis of sustained yield. A census, even if taken but once a year in the early fall, is a useful instrument, serving as a basis for judging the success of the current season's crop. When census operations are carried out more frequently, the manager not only obtains information concerning the population at a particular time but is better able to observe trends, to predict developments, and to manage his crop intelligently.

The Complete Census. This method is more thorough and more reliable than others described later. Where accurate information on populations is required, it is the correct procedure to follow. A complete census is made

by traversing the given area at intervals, recording birds as they flush. Birds flushed more than once are not recorded. The interval to be used between lines of travel across an area is a variable factor dependent largely upon cover conditions.

The success of this method depends to a great extent upon the care with which the census taker "beats" his area and the judgment he exercises in eliminating birds previously flushed. Errors in this respect are likely to occur, even when each bird is observed carefully and its flight recorded on a map. However, errors of this nature rarely become a serious factor when the work is well done.

The census is accelerated if several men attack the problem in unison. Bird "drives" are quite accurate and rapid but require more men and money than the results warrant. Ordinarily, one to three men are more efficient than a larger number and accomplish their objective satisfactorily if given sufficient time.

The use of trained bird dogs has been tried successfully by Wight (58) in Michigan, Randall (49) in Pennsylvania, and Wandell (56) in Massachusetts. Three different breeds were used satisfactorily, but Wight believes that only a highly trained animal is suitable for this type of work. Aside from the ordinary qualifications of being able to locate the birds and to distinguish between them and domestic animals, the dog must be highly intelligent, tractable to commands, possessed of a considerable capacity for independent movement, and able to work long hours under trying circumstances. Moreover, the handler must be an experienced man who understands his dog and knows his business. The inexperienced or impatient technician is not likely to succeed with this method of census and will do well to adopt some other procedure.

During May and June dogs lose their ability to detect game, and at this season their usefulness in census work is negligible.

Crowing Cock Census. This census method is described by Ammann (2), who used it in Michigan where a heavy population of pheasants was present on range accessible by car. He first determined, by direct observation, the number of times on the average that a cock crowed in 1 hour. Next, he found by observation and various tests that he could hear any cock crowing within approximately ½-mile radius, which furthermore encompasses an area slightly less than ⅘ of a square mile. With his basic information he set about taking the census by recording on clear days the number of times cocks crowed between sunrise and 8 A.M. during 1-hour periods. This figure divided by the previously determined average for a single cock will give the crowing-male population within hearing distance. The month of May gave the best results in central Michigan.

This method, though relatively simple in theory, has at least three

limitations. It records male birds only; it is usable only during the crowing season; and the determination of hearing distance is complicated by a number of factors beyond control, such as roughness of terrain, character of vegetation, and atmospheric conditions. On relatively flat, unbroken country like the prairies, the method is probably satisfactory, but elsewhere it should be used with caution.

Road Patrol Census. This method developed by Bennett and Hendrickson (5) is used in Iowa and Pennsylvania. The census is based upon an index secured from a count of the birds seen along little frequented country roads between dawn and 8 A.M. The count itself is obtained from a car driven at a speed (15 to 20 miles per hour) not so great as to frighten the birds unduly. By correlating the number of birds seen per mile with the known population of the area covered (this information must be determined by a complete census or known in some other way), it is possible to compute an index by which populations can be estimated for similar tracts or on the same tract at a future time. An index determined in one locality should be used in another only if conditions, especially cover conditions, are comparable. Bennett and Hendrickson (5) derived the following indices:

No. of Birds per Mile	Equivalent Population, Acres per Bird
8–10	4–5
2	7–9
1	18

Einarsen (16) has developed a system of pheasant census for Oregon conditions that he calls the "quadrat" inventory. In this method he selects a location in average pheasant range and marks out a line of travel around the perimeter of a rectangular plot of land approximately a mile on a side and $\frac{1}{4}$ mile wide. The location of the beginning of the line and its course are marked in detail so that all later counts may be made along the same route. The census taker traverses the area along the line and records the game seen. The count is made on a strip 100 feet each side of the line of travel.

Selection of the sample quadrat is accomplished by a trained technician who knows both pheasant habits and pheasant ecology. The census operation may be conducted by any wide-awake individual who is willing to follow instructions and record what he sees. Certain rules are necessary to get uniform and satisfactory results. These are

1. Begin the census not earlier than 8 A.M., and cease operations between 11 A.M. and 2 P.M. on hot days. Also do not conduct census counts on wet or stormy days.

2. Einarsen gives August to December as the best inventory months

for Oregon, with March and April also as satisfactory unless storms prevail. He likewise points out that the summer months are less satisfactory because of the lush vegetation, which, though affording excellent concealment for birds, creates poor conditions for observing them.

3. Concerning the extent of the sampling, Einarsen maintains there should be 1 quadrat for 5,000 to 20,000 acres and 10 to 30 quadrats to each ecological unit.

4. The sexes and age classes of pheasants should be listed separately as males and females, adults and juveniles. All other wildlife species such as bobwhite, cottontails, etc., should also be listed.

5. Under conditions where the bird density is more than one bird per acre, Einarsen suggests enumerating all birds seen rathe than limiting the census to a 200-foot strip. If birds flushed beyond the 200-foot strip are listed, then the sample area is calculated on the basis of the bird flushed most distant from the line of travel.

6. In calculating the population from census data, Einarsen suggests multiplying the perimeter of the quadrat in feet by 200 or by twice the distance of the bird flushed farthest from line of travel (see immediately preceding paragraph) with the product divided by 43,560. If the results of these calculations are divided by the number of birds on the sample, the acres per bird are found. A census of 4 to 5 quadrats by one person in a day is possible or a travel distance of 18 to 23 miles.

Several additional census methods have been tried by McClure (45) in Nebraska, including a count of crowing males in response to a detonation bomb. The bomb is exploded at space intervals of 5 miles. The enumerations are made during the morning hours. Counts taken during the afternoon are not comparable to those made in the morning. Another method was the counting of droppings on plots 1 yard square and on strips 1 by 6 feet in winter-roosting grounds.

McClure also suggests making a count of the pheasants along a 15-mile ride on horseback in which the choice winter habitats are visited. This gave uniformly good results but is definitely a winter type of census. Furthermore, it is practicable only under conditions where the terrain is open and fences do not interfere.

Evaluating the Pheasant Range. Intelligent management is predicated on several factors, one of which is a thorough knowledge of the area to be managed and its suitability as a habitat for various kinds of wildlife. The quality of a given range can be estimated *in general and intangible terms* by any experienced observer who is familiar with the ground and understands the ecological requirements of its animal population. At this stage in the development of wildlife management, such procedure may be and usually is the only method available. *But it is little more than an educated guess at*

best and subject to many errors. The ideal measure would be a more detailed and exact rating expressed in its final form as a numerical value, based on the individual evaluation of the various habitat elements that in the aggregate comprise the range. If these elements are amenable to quantitative measurement, the ideal has been realized. A technique of this sort not only serves as a more reliable measure of range quality but provides a standard procedure by which the value of any and all ranges can be determined on a comparable basis. Unfortunately, reliable "yardsticks" of this nature are lacking for most game species. Wight's (61) proposal for evaluating pheasant range is a step in the right direction.

TABLE 22. PLAN FOR RATING PHEASANT RANGE SHOWING THE BASIS OF EVALUATION AND THE SPREAD OF EVALUATING UNITS (61) *

Basis of evaluation	Rating on basis of numbers		Rating on basis of size and quality				Combined rating, per cent †
	Numbers per square mile	Rating	1	2	3	Av.	
Winter roosting sites.......	4 or equivalent	0–10	..	..	..	..	0–10
Food units................	8 or equivalent	0–10	..	..	..	..	0–10
Crowing areas.............	40 or equivalent	0–10	..	..	..	..	0–10
Nesting sites...............	40 or equivalent	0–10	..	..	..	..	0–10
Rearing grounds...........	40 or equivalent	0–10	..	..	..	..	0–10
Sanctuary areas............	4 or equivalent	0–10	..	..	..	..	0–10
Interspersion of cover types..	....	....	..	..	..	..	1–10
Distribution of units........	....	....	..	..	..	..	1–10
Communication (travel lanes)	....	....	..	..	..	..	1–10
Adaptation to management..	....	....	..	.	.	..	1–10
Total....	....	....	..	..	..	..	4–100

* It should be pointed out that according to this evaluation scheme it is possible for a range to receive a theoretical rating of site I (90 per cent) that has no real practical significance This occurs when the paramount factor, "food units," is rated as 0 per cent. The complete absence of this all-important item will, of course, make a range uninhabitable even when all other factors are present to perfection.

† "Rating on basis of numbers" divided by "rating on basis of size and quality."

Wight first breaks down the range into its component elements, such as roosting sites, food units, and similar items, which are then examined in the field and evaluated on the basis of size, quality, and number per standard unit of 640 acres of range. The final rating for the range as a whole is derived from the individual ratings of these several parts. Tables 22 and 23 illustrate the method.

In using Wight's system of evaluating pheasant ranges, the total percentages obtained under "combined rating" can be reduced to a final rating figure based upon the following scheme:

TABLE 23. SAMPLE RATING SHEET FOR EVALUATING PHEASANT RANGE SHOWING THE METHOD OF COMPUTING THE FINAL RATING (61)

Basis of evaluation	Rating on basis of numbers		Rating on basis of size and quality				Combined rating, per cent
	Numbers per square mile	Rating	1	2	3	Av.	
Winter-roosting sites (4)	2	5.0	1	0	1	2.0	2.5
Food units (8)	6	7 5	2	1	3	2.2	3.4
Crowing areas (40)	16	4.0	6	3	7	2.1	1.9
Nesting sites (40)	14	3.5	5	5	4	1.9	1.8
Rearing grounds (40)	20	5.0	6	9	5	2.0	2.5
Sanctuary areas (4)	0	...	.			. .	0
Interspersion of cover types	.	...	. .	. .	.	. .	4.0
Distribution of units	. .	...	. .	. .	.	. .	3.0
Communication (travel lanes)	. .	...	.	.	. .	. .	6.0
Adaptation to management	. .	...	. .	. .	. .	. .	5.0
Total	. .	...	. .	. .	.	. .	30 1
Final rating	. .	...	. .	. .	.	. .	III

BASIS FOR FINAL RATING

Sum of Combined Ratings	Final Rating
1–25	IV
26–50	III
51–75	II
76–100	I

Food Development. A constant supply of good food is absolutely essential if a high population of pheasants is to be maintained. Over most of the pheasant range, food supplies are generally adequate during summer and fall seasons. The crucial period comes in the late winter and early spring, when food materials from the preceding growing season are either exhausted or inaccessible and no new source is yet available. During this period of comparative scarcity special precautions may be needed to augment the natural supply.

This problem is most satisfactorily met by supplying supplementary food from domestic grains, such as leaving standing or shocked corn near winter-roosting sites. Interplanting of soybeans with silver-hull buckwheat during the last cultivation, sometime after July 1, is also effective. Both grains produce large quantities of seed. The weak-stemmed buckwheat tends to become prostrate early in the winter, but the stiffer stems of the soybeans help to hold it in place. Although the soybeans are less palatable than the buckwheat, the combination has the virtue of affording both a food and a concealing cover that stands up well even under adverse

snow conditions. Some varieties of soybeans such as cayuga, though less attractive, hold the bean grains in their closed pods from the time of ripening until as late as June of the following season (47).

Frequently, it will be cheaper to use grains that are a part of the crop regularly grown on the farm—wheat, barley, oats, rye, and corn. In

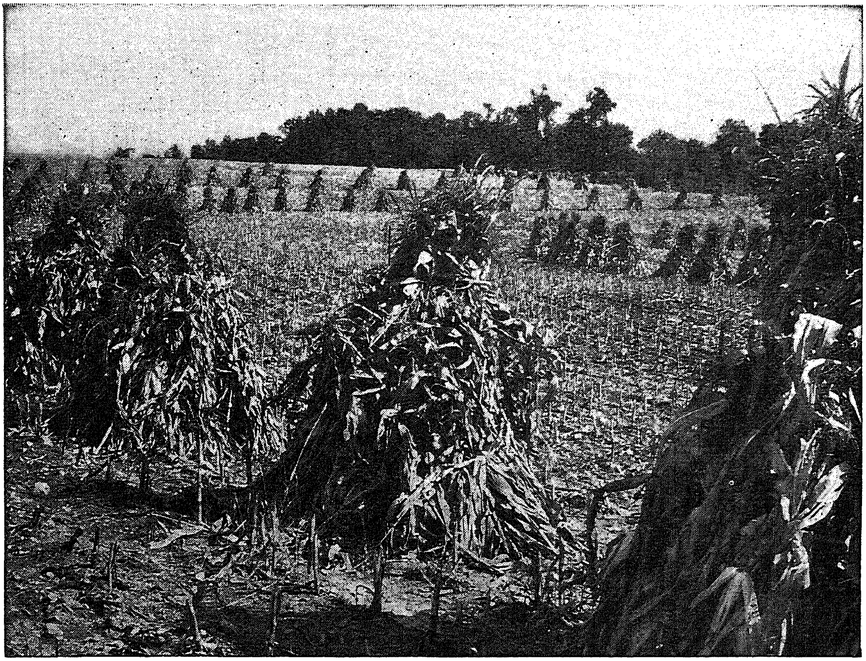

FIG. 4 · 4. Corn, the most important supplementary winter food for wildlife. Corn in the shock makes excellent self feeders for bobwhite, pheasants, squirrels, and cottontails. Loosely shocked cornstalks give protection to feeding animals and hold the grain above the snow. Weeds and fall planted grains in cornfields produce added attractiveness. Nearness of cover is one of the essentials of shocked corn left for wildlife. (*Soil Conservation Service.*)

Pennsylvania standing corn is considered so important to the pheasant that classification of the pheasant range is based on the percentage of corn left standing during the winter. If 7 to 10 per cent of the land area is in standing corn the range is considered satisfactory for a dense pheasant population. Four per cent is considered essential for a good population (44). Corn has the disadvantage of being such a favored food among all of the common farm-game species that it is likely to be consumed before the real crisis comes. Moreover, it is subject to the ravages of the corn borer, and control laws in many states provide that cornstalks must be removed from the field before Dec. 1.

Both alsike and June clovers furnish desirable succulent growth during

all seasons once they become established. These materials may be planted in separate patches or sowed with the various mixtures of grains. This latter practice is particularly practicable when the grain patches are rotated from year to year. The grains mature the first season; the clover becomes dominant the following season.

Food patches are best placed near cover, preferably cover that is used during the winter, such as evergreen trees or windbreaks. Food plantings can be located next to kettle holes, fences, hedgerows, wood lots, or herbaceous marshes. Long, narrow patches are better than square ones and should be no larger than an acre in extent. Several small patches, well distributed, are preferable to one large one. Occasionally, fencing against livestock may be necessary.

Perennial food plantings provide excellent supplementary food. Where seed of annual plants is reasonably abundant, additional plantings of this type may be all that is needed to ensure an adequate food supply during the winter. The initial effort in setting out perennial plantings probably exceeds that required to plant annual food patches; but once the perennials are well established, they serve their purpose year after year with very little additional attention.

The following plants are recommended for pheasants: the wild roses, bittersweet, the dogwoods, wild grape, black alder, and coralberry. Black alder is particularly well adapted to wet swampy grounds where it normally grows naturally. Of the dogwoods, panicled dogwood is excellent. Over much of its range it is the most common of this genus; and because it so frequently grows in dense thickets along fence rows and woodland borders, it furnishes dense cover as well as food. These shrubs often occur so abundantly that additional plantings are unnecessary. For further information on food patches and the planting of perennials, the reader is referred to Chap. I, *The Farm as a Wildlife Habitat.*

Emergency feeding during the winter may become necessary when natural food supplies fail. This method of feeding is less desirable than providing adequate food patches and perennial plantings and ought to be regarded wholly as an emergency measure. The chapter on *Winter Feeding* covers this matter in detail.

Cover Development. The development of cover is a more difficult problem than that of food, for less is known of animal cover requirements. Improvements are most likely to be needed on farms where shrubby and wooded cover types are scarce or lacking, especially in Middle Western states on land devoted primarily to the production of grain. Eastward, cover is not often a problem. In developing this phase of management it must be remembered that several types of cover are needed: roosting cover, crowing areas, feeding cover, escape cover, and lanes between roosting and feeding sites.

Natural cover may be created in two ways: by planting suitable materials in locations where cover is needed and by the protection from grazing of certain areas that develop their own cover. Fence rows, odd corners, marshes, and other types of wasteland, if allowed to develop naturally, soon grow a stand of shrubs and trees that not only furnish cover but supply food as well. Plantations, hedges, and windbreaks all fit into the program.

Artificial cover in the form of brush piles and shelters is easily constructed where natural cover is not satisfactory.

Predator Control. Predator control in most instances can be limited to the red fox, the skunk, the great horned owl, the Cooper's hawk, the crow, and the house cat. No attempt should be made to eliminate any predatory species completely, because of the secondary or related results that may follow. Moreover, pheasants reared in the wild with abundant food and adequate cover at their disposal usually are capable of caring for themselves.

Foxes and skunks can be controlled by trapping during the season when fur is prime. The skunk, however, is such a useful and valuable fur bearer that control should not be attempted except when particularly destructive individuals are doing damage to nests. The general reduction of this animal is not warranted, for only an occasional individual is likely to cause trouble.

House cats that have to hunt for their living are destructive to all bird life and should be controlled by shooting whenever found in the wild state. However, care should be exercised not to kill well-fed, relatively harmless pets. Such cats will ordinarily be found near occupied houses and are not likely to be so destructive as the feral type of feline.

Miscellaneous Management Procedures. The release of artificially reared pheasants has been the most popular form of pheasant management practiced in the United States. Stocking is necessary on range where the birds are not yet established or where hunting depletes the breeding stock each season. The initial cost of released birds varies from $1.50 to $2.50 apiece, and the ultimate cost of those which finally become established may be considerably higher if some fail to survive or disperse to other range. Wight [1] found on one experimental area in Michigan that producing pheasants by environmental improvements cost 47 cents per bird and 7.8 cents per acre. To this saving in monetary cost can be added the intangible value that the sportsmen derive from hunting more vigorous wild birds (35).

The survival of artificially reared stock has been inadequately investigated, but results obtained by Wandell [1] on an experimental tract in Massachusetts suggest that mortality among released birds may be significantly

[1] Unpublished data made available to the author.

greater than among wild birds. The death rate among this group was roughly double that of the established residents. Buss (10) gives excellent evidence to show that the returns to the hunter of artificially reared birds vary depending on the time elapsed before hunting begins. Early releases give returns of 10 to 20 per cent, but releases made just before hunting begins may run from 40 to 81 per cent. Survival of released birds the second year runs only 4 to 7 per cent.

The proper season for releasing artificial stock is a much debated question. Adult birds have been released during the spring breeding season and preceding or following the hunting season. For stocking, immature birds of all ages have been used—from a few days to several weeks old. Stocking adult birds in the early spring is expensive and places the birds in the field at a time when food and cover are at their poorest. Releasing males in the fall and females in the spring allows the latter to be held longer without injury from the pursuit of males, reduces the cost of carrying the cocks through the winter, and frees the hens in the best possible condition for laying a clutch of eggs.

The release of day-old chicks with broody domestic hens has been tried successfully (59) but requires special equipment and careful administration. However, it seems a worth-while method which merits further use.

The customary method of stocking involves the release of birds 12 to 16 weeks old during September. This procedure has gained favor because it complements the production methods now practiced by most game farms. A better procedure would be to release the birds earlier before the insect population attains peak proportions in late August and September, but this improvement can be effected only if breeding birds are brought to a breeding condition before the normal mating season (7).

Tubbs (54) gives a summary for the survival of banded, pen-reared birds in Michigan as 8 to 9 per cent return when released 1 month before the opening of the hunting season, 6 to 8 per cent return for birds released 2 to 3 months before the open season, and 1 to 2 per cent return for birds released 11 months before the open season. The cost of cocks actually bagged was $16.20 based on the above returns and an initial cost of 90 cents for each pheasant at the time of release. A total of 8,458 birds was released in this experiment. Probably not all bands were returned, so the actual cost of birds bagged is somewhere between 90 cents and $16.20. Contrast this to a cost of 47 cents per pheasant by environmental control as given by Wight.[1] This should be a disturbing revelation to advocates of better hunting through release of artificially reared birds.

A method of restocking that has proved satisfactory is the trapping of birds raised on refuges and released on adjacent shooting areas. A simple

[1] Unpublished data made available to the author.

wire trap is used for this purpose. To accustom the birds to its presence, the trap is set up several days in advance of trapping operations, without the cover and baited with corn. Eventually, when the birds overcome their fear and enter and leave the trap freely, the cover is replaced and trapping begins. Because the birds tend to injure their heads by flying up against the wire cover, it is good practice to stretch fish netting across the inside a foot or so below the top.

Cumbersome as the contraption appears, it can be assembled, dismantled, and transported with surprising ease. The stakes are cut at the trapping site, and only enough staplings are needed to keep the wire from shifting in position. In fact, some technicians dispense with the stakes entirely, relying upon the stiffness of the wire to hold it upright and pegs at the bottom to retain it in place.

Kutz (38) of New York suggests a trap made of welded wire fabric with a protective "skirt" of chicken wire, except at the entrance funnel, to prevent damage to the trapped birds by dogs and ground predators.

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CHAPTER V

BOBWHITE QUAIL

(*Colinus virginianus* Linnaeus [1])

GEOGRAPHICAL DISTRIBUTION

There are few native game birds of North America that are more highly esteemed than the bobwhite. In this role it reigns supreme in the Southern and Central states, but northward near the limits of its range the bobwhite is frequently regarded as a songbird. Wherever the bobwhite quail occurs, from the Atlantic to the Pacific coasts, it is popular with both the farmer and the naturalist. Its pert and saucy appearance, its pleasing manners, and cheery "bobwhite" call have won the hearts of many persons. Moreover, it takes keen delight in helping to rid gardens and fields of insects and apparently has no bad effect upon crops.

The range of the bobwhite lies primarily in the eastern United States, extending from Texas, Colorado, and the Dakotas on the west to central Minnesota, Wisconsin, New York, and New England on the north, the Atlantic seaboard on the east, and the Gulf of Mexico on the south. Westward, particularly in the Northwest, it has been introduced successfully and is now established in several isolated localities (32) (see Figs. 5·1 and 5·2).

The northern limit of its range fluctuates with the severity of winter weather, gradually extending northward during consecutive years of mild winters and southward again with the return of an extremely severe winter. The northward extension is a gradual process which reaches out a little farther each year, but the southward retraction is very abrupt, usually requiring but one severely cold winter with snow remaining on the ground for weeks to kill the bulk of the population on this part of the range. As a result, the northern limits of distribution fluctuate from year to year and over an extensive period may vary by as much as 100 miles. This phenomenon is less sharply manifested along the New England coast because of the moderating effect of the ocean. Inland, Leopold (*66 g.r.*) speaks of what he calls an *irruptive* type of population which occurs on a highly

[1] The range and a few additional notes are given for the following species: Gambel quail, *Lophortyx gambeli* Gambel; Valley quail, *L. californica vallicola* Ridgway; California quail, *L. californica californica* Shaw; Scaled quail, *Callipepla squamata pallida* Brewster; Mountain quail, *Oreortyx picta palmeri* Oberholser; and *O. picta picta* Douglas.

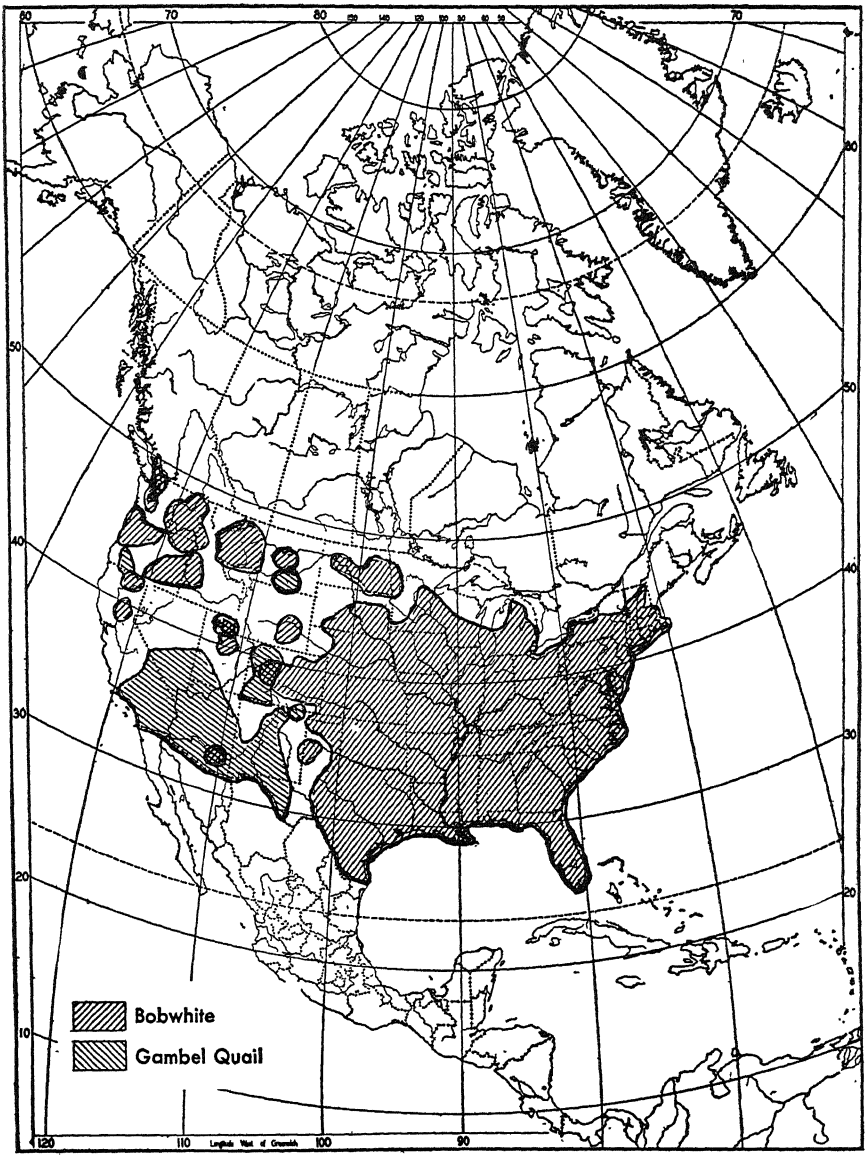

FIG. 5·1. Ranges of the eastern bobwhite and Gambel quail. (*By Robert McClanahan*, 32)

productive range within this tension zone. There, the population flares up to an extremely high peak during favorable years, only to be cut back to nearly zero by the periodically severe winters.

Leopold (28) has illustrated the lethal effect of severe winter weather on

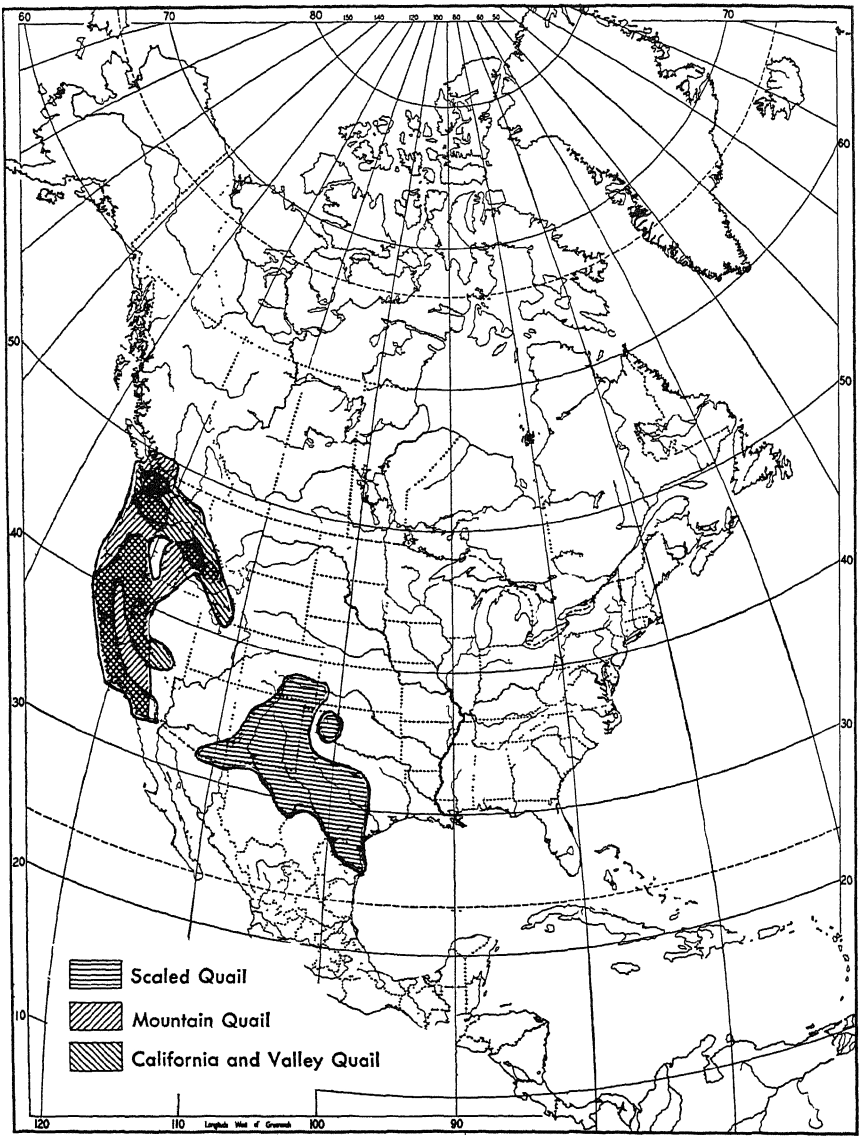

FIG. 5 · 2. Ranges of scaled, mountain, California, and valley quail. (*By Robert McClanahan*, 32)

bobwhite quail by plotting the inches of unmelted snow on the same graph with the daily minimum temperature. The area of graph between the lines representing these two weather factors is designated as lethal units. The graph representing the severe winter of 1935–1936 at Madison, Wis., is taken as 100 lethal units. Leopold indicates that even prime heavy birds

with plenty of good-quality available food may be killed when subjected to weather conditions such as prevailed in southern Wisconsin in 1935–1936.

LIFE HISTORY AND ECOLOGY

Breeding Characteristics. Mating. The sex ratio of bobwhite quail is not known for juvenile birds, but among adults the males appear to outnumber the females, the discrepancy becoming more pronounced as the season advances. This unbalanced ratio is variously attributed to the hardier nature of the males and the fewer dangers to which they are exposed. Published data place the ratio at about 53 males to 47 females (31, 35, *65 g.r.*). Among Gambel quail, the ratio appears to be less divergent (20), and there is evidence that for this species the two sexes apparently occur in about equal numbers. According to Emlen (6) the sex ratio of more than 15,000 California quail was found to be slightly more than 56 males to 50 females.

The bobwhite, unlike many other game birds, is monogamous. With the first warm days of spring, the birds begin to pair off, and soon the winter coveys have broken up and dispersed to the spring breeding range. This activity depends upon the weather and hence varies somewhat from year to year as well as among localities. In the South the breeding season may commence as early as mid-February (35); northward it starts progressively later. The first "bobwhite" whistle of spring is a sign that the mating period has arrived.

Each pair of birds select a mating territory where the pair remain until the young are able to leave the nest. Frequently during this period the males from adjoining territories fight among themselves but rarely suffer serious injury. Later the males become less quarrelsome, to the extent that several mated pairs may nest on 1 acre of nesting ground without undue friction. The tie between a mated pair is a strong one, the male remaining in attendance throughout the summer season and assisting the female in tending the brood. In fact, the bond between a mated pair may continue for several years, although it is not very evident among birds in the winter coveys—a relationship that is more highly developed in the bobwhite than among most other gallinaceous game birds.

The Gambel and California quail resemble the bobwhite in their mating behavior, except that the mated pairs of western quail finally leave the covey only when the period of incubation has begun. Until that time, while mating is in progress and the eggs are being laid, the birds of the covey commonly roost together. Male Gambel quail begin to select mates early in the formation of the winter flocks, following them about and otherwise making known their interest by displaying their plumage and pointing out choice bits of food. Fights among the cocks are frequent and often of

extreme ferocity, inflicting injuries that Gorsuch (20) believes may be fatal at times. In normal years mating is complete and nesting has begun by Apr. 1.

Among other quail, mating and nesting activities are probably well under way by June and frequently much earlier. According to Dawson (*20 g.r.*), the California valley quail begins courtship in March or early April. Like the bobwhite and Gambel quail, it also is monogamous.

Nesting. The nest of the bobwhite is built on the ground in orchards and old fields and along fence rows, streams, woodland borders, and roadsides. Herbaceous rather than wooded cover types are preferred, although woody vegetation is usually present. Stoddard (35) found that nests in Georgia were distributed as follows:

Nesting sites	No. of nests	Per cent of total
Broom sedge fields	336	56
Woodland	97	16
Fallow fields	88	15
Cultivated fields	23 (approx.)	4 (approx.)
Not classified	58 (approx.)	9 (approx.)
Total	602	100

Of perhaps more significance than these data (Stoddard states that they are not entirely satisfactory because the woodland type was poorly represented) is the fact that "more than 82 per cent of the nests were in growth sufficiently open at the birds' level for them to run about freely, while . . . not quite 7 per cent were in really dense growth, and most of these were near the edge of it." Seventy-four per cent of the nests were located within 50 feet of roads, paths, fields, and similar openings.

The nest usually occupies a shallow depression on the ground lined with grass and similar debris. Frequently, a covering of grass partially conceals the nest but at the same time permits the incubating bird a view of its surroundings. Individuals of either sex may build the nest, and either may incubate the eggs, although normally the hen carries the burden of responsibility in both operations (10). The nesting period commences in late April or early May and continues until late summer.

The average clutch is 14 eggs but varies from 7 to 37 (*20 g.r.*). This maximum number of eggs perhaps represents the product of more than one female, since it is known that two or more birds occasionally lay their eggs in the same nest. Clutches are larger early in the season and are reduced as the season advances (10). Concerning the maximum egg-productive capacity of these birds, it is interesting to note that individual bobwhites raised in captivity have laid well over 100 eggs in a single season (21). Eggs are white to light brown in color and smaller than bantam chicken

eggs. Normally, each pair of mated birds raise one brood per season. Under natural conditions if the first clutch of eggs is destroyed, the hen may lay a second or even a third clutch. Should the hen die or be killed, the male incubates the eggs and rears the young. The incubating bird leaves the nest to feed once each day for a period that varies from one to several hours (35). While the egg-laying period may take up to 20 days, apparently the incubation period begins for all eggs of a clutch at about the same time as the eggs hatch, within a 24-hour period according to Studholme (38). The same author gives the period of incubation as 23 or 24 days and the usual viability of eggs in the wild state as 85 to 95 per cent (21, 38). An additional 5 per cent of the eggs may be fertile but do not hatch because the chicks are too weak to extricate themselves from the shell. Stoddard believes that weather conditions play an important part in the success of the hatch. (For further details on nest success see the section on Mortality.)

The nest of the Gambel quail (*20 g.r.*) resembles that of the bobwhite except that it contains not only grass but feathers from the female's body and is more thoroughly concealed, even to the extent of being placed sometimes in the ground dens of mammals. Incubation requires 21 to 23 days, and the clutch contains from 7 to 20 eggs, well camouflaged by their mottled markings. The male does not participate in the process of incubation but stands guard near by, where it attempts to divert the attention of intruders and lead them away from the nest site.

Nests of the scaled quail (*20 g.r.*) are located under the shelter of low shrubs and similar growth, such as cactus, sagebrush, creosote bush, mesquite, or yucca. Occasionally they occur in more open situations among rocks. Each nest contains from 9 to 16 eggs, usually 12 to 14, which vary in ground color from dull to creamy white and are marked variously with small light brown speckles. Incubation requires 21 days. Occasionally two broods are raised and sometimes three during the same season.

The valley quail builds a simple nest which may be placed in a variety of locations such as brush piles, clumps of grass, or even at the base of haystacks.[1] It frequently builds no nest at all, laying its eggs in the nest of other ground-nesting birds. Twelve to sixteen buff-colored eggs marked with darker spots compose the usual clutch, although larger clutches may occur. Eighteen to twenty-three days are needed to incubate the eggs, and one brood per season is the rule.

According to Sumner (40) and Grinnell [1] California quail hatch but one brood a season and have a minimum incubation period of 23 days.

Bent quotes Bendire as stating that the nest of the mountain quail,

[1] GRINNELL, J., H. C. BRYANT, and T. J. STORER. 1918. The game birds of California, University of California Press, Berkeley.

Oreortyx picta palmeri, "is placed on the ground, alongside or under an old log, or on sidehills under thick bushes and clumps of ferns, occasionally along the edges of clearings, grainfields, or meadows." Nesting begins in May. The eggs vary in color from pale cream to reddish buff and are entirely unspotted. The other subspecies of mountain quail, *O. picta picta,* also known as the plumed quail, is a bird of semiarid wooded areas and builds its nests under brush piles and in denser cover than the preceding subspecies. Its eggs resemble those just described and number 10 to 12 per clutch. The incubation period lasts 21 days. At lower elevations, two broods may be raised, the male caring for the first while the female is hatching the second.

Rearing of the Young. Few sights are more interesting than a family of bobwhites on the move, the mother leading the way with a dozen or more fuzzy chicks following in single file and the father bringing up the rear. Few animals show more devotion to their family; and incidentally, few are more successful in rearing their young. The chicks are able to walk almost immediately after hatching and soon afterward leave the nest with the parent birds.

During the remainder of the summer, fall, and winter the family lives a nomadic life, pursuing no routine movements as do many other birds. Instead they travel here and there wherever food and cover are attractive, although remaining in the same general vicinity. For the first 2 weeks, the newly hatched chicks, lacking well-developed feathers, are unable to fly and at night cuddle close to their parents for warmth and shelter; thereafter, they are able to survive independently but rarely leave the family group unless by accident.

Among the other quail previously mentioned, the typical mode of existence, though differing in some respects, is not unlike that of the bobwhite. Among these species, as with the bobwhite, the family bonds are strong.

Movements. The daily movements of the bobwhite in search of food, shelter, and escape cover and, for that matter, its seasonal movements are restricted to a relatively limited range. Despite the short cruising radius, however, the bobwhite is a roving type of bird in the sense that it has neither any particular feeding grounds nor any particular roosting cover, roaming whither conditions tempt it and resting wherever night overtakes it. The birds roost on the ground for the most part, the entire covey crowding together in a closely packed circle, heads outward and tails pressed so tightly against one another that they stick straight up.

Stoddard (35) found in the Southeast that of marked adult birds released and recaptured, 48 per cent were recovered within 1/4 mile of the banding locations, 28 per cent within 1/4 to 1/2 mile, 14 per cent within 1/2 to 1 mile, and only 9 per cent from greater distances. One bird was retrapped in the original range 36 months after banding, and another only

400 yards away after 45 months. Errington (9) in a similar experiment in Wisconsin reports that less than 8 per cent of the bobwhites recaptured were taken beyond ¼ mile from the banding station. All of which indicates that the seasonal cruising radius of adult birds rarely exceeds 1 mile and is usually less than half that distance.

In localities where the range of the birds is advancing, as in the northward extension of the limits of distribution during periods of favorable climatic conditions, seasonal movements may exceed considerably the average for birds in regions of comparatively stabilized populations. Leopold (*65 g.r.*) believes that under such circumstances an unmated cock may travel as much as 10 miles in search of a mate.

With respect to juvenile birds Stoddard (35) found that some traveled several miles but the majority moved less than ¼ mile in 200 recorded cases, only six went farther than 1 mile, and the greatest distance was 7 miles.

During the winter bobwhites travel in coveys of 5 to 30 composed mostly of birds from one or two families plus "strays" detached from other groups. The activities of each covey are largely confined to a specific range, although it may occupy only part of it for several days at a time. In an area of high population density the ranges of neighboring coveys may overlap. By late winter or early spring the birds begin to pair off, and soon afterward the covey disperses by pairs to mate and rear broods.

In western Oklahoma bobwhites have a seasonal movement by which the birds disperse from the upland pastures to the better cover of the bottom lands or the sand dunes for the coldest part of the year (2, 4). The movement from the uplands to lower elevation does not include the entire population but involves the birds living in the poorer cover or marginal part of the range. This movement of birds may involve a shift of population for distances of 3 to 10 miles.

The western quail (*20 g.r.*) form winter coveys like the bobwhite, while the Gambel and valley quail congregate in large flocks that sometimes may reach 200 in number. Emlen (5) describes a dispersal type of movement for California valley quail from the restricted winter range to more ample summer or breeding range. The extent of this expansion is not given, but it follows the general pattern of eastern bobwhites. Mountain quail have the highly interesting habit of moving in a kind of transhumance migration, which takes the coveys up the mountains in summer and down in autumn to below the winter snow line. The movement is gradual and almost wholly on foot. Occasionally during the winter, remnants of flocks broken up by hunters, generally cripples, remain above 5,000 feet, but most of these succumb to the rigors of the severe climate. Migration among the other quail covered in this chapter is not known to occur.[1]

[1] Grinnell, Bryant, and Storer. *Op. cit.*

Cover Requirements. The bobwhite is a bird primarily of farm lands, thickets, and open woodland. It rarely occurs in any great numbers on heavily timbered lands of extensive area devoted principally to the production of forest crops but thrives best on lands of diversified cover well interspersed in small units. Ideal range contains about equal proportions of cultivated crops, ungrazed grassland, brushland, and woodland (*66 g.r.*).

In the Southeast, however, quail thrive under a canopy of forest trees if the forest is not too dense and the correct interspersion of cover types is maintained. Stoddard and Komarek (37) indicate that the correct porportion of openings should be about 25 per cent of the entire area, distributed in small fields. They object to large fields in which clean cultivation is practiced and also speak of the detrimental effects of heavy all-year grazing.

The growing of hedges and windbreaks and the introduction of grain crops were sufficient to extend the range of the bobwhite westward into the treeless plains states; the cutting of woodlands and the development of agriculture extended its range northward in the Lake states and probably also in New York and New England. In each case the improved habitat resulted from changes in vegetative conditions that broke up extensive areas of continuous cover and introduced diversification.

The success or failure of cover as it contributes a suitable habitat for bobwhite depends almost wholly upon the character of the ground vegetation. Where suitable ground cover is lacking, conditions are poor; where it occurs in impenetrable tangles of great density, the situation is also poor. A degree of development and denseness intermediate in character satisfies bobwhite requirements admirably. Cover of this nature provides shelter and protection, permitting the feeding birds to move about freely and encouraging the growth of desirable food plants. This explains why the open pine woodlands along the Southern Coastal Plain provide a favorable environment if properly handled. In the hardwood forests of the North, on the other hand, both canopy and understory are usually so dense that herbaceous food plants are lacking in sufficient volume to encourage quail tenancy. In the same way ungrazed grassland is generally superior to pasture land because the latter supplies neither cover nor food in quantity.

The often expressed axiom "that the bobwhite does well where agriculture is practiced" is a reasonably accurate statement when applied to a primitive type of farming in which weedy fields, brushy fence rows, and odd corners supply an abundance and variety of suitable cover. In contrast to this, the more intensive forms of agriculture that follow the policy of "clean farming" are decidedly detrimental to quail, for wherever the latter methods are practiced, a diminution in bobwhite numbers is to be expected (37). However, it is equally true for forested regions that abandoned

agricultural lands in the state of reverting to nature soon become equally undesirable, because here cover develops in such volume and density that quail have difficulty making their way about, and herbaceous growth gradually disappears before the superior competition of invading woody species. A similar condition sometimes develops in the Southeast, where abandoned farm lands frequently revert to broom sedge, a cover type characterized by great density and a paucity of food plants. Westward, where grassland types are favored by climate and dense forests rarely develop, the abandonment of land and the successional changes that follow are less likely to exert an adverse influence upon habitat conditions. In fact in many cases the effects of these factors actually may be beneficial.

For purposes of escape from predators such as the ever-dangerous Cooper's hawk and sharp-shinned hawk, a denser cover than that normally frequented is to be preferred. Brush piles, tangled thickets, and fallen trees with untrimmed branches meet these requirements. A range to be highly productive of bobwhite should be well supplied with retreats of this character.

Scaled quail and Gambel quail are birds of the arid and semiarid regions of the Southwest and northern Mexico. The typical habitat varies somewhat, but in general these birds inhabit lands covered with scattered growth of creosote bushes, sagebrush, mesquite, cacti, and similar plants typical of these sites. They also occur in the cottonwood bottoms found along streams. The valley quail is somewhat like the bobwhite in that it, too, frequents farm lands if brushy hillsides, grassy fields, and orchards are present.

California quail ordinarily roost in shrubs or trees rather than on the ground.

Mountain quail restrict their activities primarily to wooded types, preferring open woodland with well-developed understories or openings in forests of denser character, especially cutover lands on which herbaceous materials have become established. Mountain quail are shy and retiring compared with some of the other quail and keep to concealing cover much of the time.

Food. Table 24 summarizes the results of an intensive study by Handley and Stoddard (35) of the principal foods and seasonal feeding habits of the bobwhite along the Atlantic and Gulf Coastal Plains and, interpreted broadly, conforms reasonably well to the general food-habit pattern of the bobwhite in other parts of its range. The preponderance of vegetable material at all seasons is plainly evident, particularly during the winter months when it constitutes very nearly the entire diet. However, it seems likely that this condition, though approached, is never quite attained. In this connection Handley found that animal matter occurred in 74 per cent of the stomachs taken during the late fall and winter (November through

February), even though this class of food amounted to only 4 per cent of the diet. During the summer and early fall, fruits and animal materials (mostly insects) form a staple part of the diet, frequently amounting to more than half of the total consumption. When these foods are no longer available in abundance, the seeds of wild and domestic plants assume an increasingly important status, which they continue to hold throughout the dormant season and the period of early vegetative growth in the spring. During these periods they provide the bulk of the food.

TABLE 24. MONTHLY AND YEARLY PERCENTAGES OF THE VARIOUS ITEMS IN THE FOOD OF 1,659 ADULT BOBWHITES IN THE SOUTHEAST (35)

Kind of Food	Occurrence of kinds of food as a per cent of the total												
	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Av.
Vegetable foods:													
Seeds:													
Legumes	*47.2*	*52 9*	*33.2*	*19.5*	*14.5*	3.4	5.7	4.0	1 3	*10.6*	*23 9*	*33.1*	20.8
Grasses and sedges	5 4	2.1	1 9	4 0	6.7	3.4	5 5	*28 3*	*43 8*	*30 1*	*11 1*	2 6	12 1
Cultivated plants	1.2	1.6	4.7	0 4	1.2	2.9	Trace	3 3	9.1	0.6	6 3	5.0	3.0
Misc.	1 8	3.6	5 3	*26.1*	*32 5*	*11.4*	*15.9*	*10.7*	7 1	*14.4*	*11 9*	3.5	12.0
Mast.............	*29.7*	*15.7*	*24.4*	*17 2*	0.8	0 4	0.1	Trace	. .	1.5	*32 7*	*38 6*	13.4
Fruit.	8 0	*10.3*	3 0	*12.4*	*17.8*	*58.4*	*51.1*	*27.7*	*24 8*	5.1	4 0	*10 2*	19.4
Forage, tubers, misc items	4 4	*11.6*	*23 9*	7 3	4.7	0.8	Trace	2 7	...	Trace	0 9	1 9	4 9
Totals..	97.7	97 8	96.4	86.9	78.2	81.0	78 3	76 7	86 1	62.3	90.8	94 9	85.6
Animal foods:													
Insects...........	1 9	1.8	3.5	*12.8*	*20.8*	*18.6*	*20.9*	*21 3*	*13.7*	*37.7*	8.7	4.9	13.9
Misc items.......	0 4	0.4	0 1	0.3	1.0	0 4	0.8	2 0	0 2	Trace	0 5	0.2	0 5
Totals..	2.3	2.2	3 6	13.1	21.8	19 0	21.7	23 3	13 9	37.7	9 2	5 1	14 4

As to individual plants preferred by southeastern quail, Handley found the following to be important:

Legumes—Lespedezas (especially Japan clover and the bush clovers), beggarweeds, partridge pea, wild sweet pea

Grasses and sedges—Paspalums, panic grasses, Johnson grass, goose grass, beard grass, and Egyptian grass and sedges of the genus *Carex*

Mast—Pines, oaks, and sweet gum

Fleshy fruits—Brambles (*Rubus*), blueberries, huckleberries, black cherry, plums, and mulberry

Miscellaneous seeds—This group is so large that no decided preference is evident, smartweeds, knotgrass, ragweeds, pigweed, bastard pennyroyal, and wild geranium being eaten most consistently

Two hundred and twenty-five quail crops collected in Alabama during the hunting season and examined by the Soil Conservation Service contained 52 species of plants, of which common lespedeza, partridge pea, and acorns accounted for about 60 per cent of the crop contents (1). Animal matter amounted to 3.4 per cent of the total.

Davison (3) in a study of 5,189 bobwhite crops taken in upper sections of the Southeast over a 3-year period concludes that two annual lespedezas, *L. striata* and *L. stipulacea*, constitute more than one-third of the food and that the above two plants together with oats, cowpeas, soybeans, beggar-ticks and partridge peas constitute about 68 per cent of all foods eaten by bobwhites in this section of the United States.

Variations in the seasonal character of quail foods are further illustrated by Massey (33), who found that the abundance of different dietary foodstuffs in Virginia reached its peak at different seasons: miscellaneous seeds in May, fleshy fruits in June and July, the seeds of grasses and sedges in August and September, insects in October, mast from November through January, the seeds of legumes in January and February, and succulent forage in March.

In Pennsylvania findings by English and Bennett (7) show that the principal plants providing food during November are lesser ragweed, corn, foxtail, wheat, and buckwheat in the order listed, seeds of these species forming in the aggregate about 70 to 80 per cent of all food consumed.

In Ohio, Hicks (24) found that the winter diet is almost wholly (99 per cent) vegetable matter, of which 19 per cent is domestic grains and 69 per cent the seeds of wild plants. Wheat and corn are most important of the grains. Among the wild plants well represented are small ragweed (31 per cent), yellow foxtail (19 per cent), various legumes (6 per cent), and smartweed (3 per cent).

Wilson and Vaughn (41) state that the more important foods in Maryland consist of wax myrtle, bayberry, ragweed, pine mast, wild geranium, Japanese honeysuckle, grasses, partridge pea, wheat, and mast of sweet gum. The plants in this list comprise about 80 per cent of the stomach contents examined.

In Wisconsin Errington (8) lists the following food materials as capable of supporting bobwhite during the winter: corn, wheat, ragweed, tick trefoil, jewelweed, smartweed, hog peanut, rye, buckwheat, soybeans, and acorns. On the other hand, when captive birds were fed exclusively on sumac seeds, locust beans, rose hips, sweet clover, and bittersweet, all lost weight and some died. This fact is of considerable interest because the materials listed occur not uncommonly in the normal bobwhite diet.

Leopold (*66 g.r.*) lists the vegetable foods of bobwhite in Wisconsin in the following order of preference:

Preferred foods	Staple foods	Emergency foods	Stuffing
Tick trefoil Ragweed	Grains Japan clover Acorns Foxtail seed	Locust beans Sweet clover seed Snowberries	Sumac berries Rose hips

The food of juvenile bobwhites, like that of other young birds, contains large quantities of animal matter, principally insects, which at first comprises the bulk of the diet but later becomes progressively less important until by late fall it forms a very minor food item. Handley and Stoddard (35) found that 84 per cent of the food consumed by 20 chicks less than 2 weeks old was of animal origin, whereas the composition of adult food at this same period was approximately one-quarter of that proportion.

A comparison of various classes of food eaten by different species of quail is given in Table 25.

TABLE 25. THE FOOD HABITS OF CERTAIN QUAIL AS SHOWN BY STOMACH ANALYSES, JUDD (25)

Type of food	Per cent of total				
	Bob-white *	California quail	Scaled quail	Gambel quail †	Mountain quail
Fruit	9.6	7.6	12.7	. ...	8.1
Grain	17.4	6.2	0.6	3.9	18.2
Misc. seeds	52.8	59.8	52.8	31.9	46.6
Foliage, etc.	3.8	22.7	4.3	63.7	24.1
Insects	15.0	2.1	29.0	0 5	2.2
Misc. animal matter	1.4	...	0.6	.	0.8
Total	100.0	98.4 ††	100.0	100.0	100.0
No. of stomachs	918	601	47	28	23

* Stomachs collected largely from the northern range of the bobwhite and none from the southeastern area covered by Table 24.

† Stomachs collected during period from January to June; other records cover the entire year although not every month in all cases

†† Remaining 1.6 per cent not accounted for.

The food habits of the western quail tend to follow, with certain exceptions, the general pattern typified by the bobwhite. Vegetable materials predominate at all seasons, and animal matter forms a larger proportion in summer than in winter. However, even though the diets of the several quail are decidedly vegetarian in character, the source of the vegetable materials varies considerably (see Table 25). Gambel quail, for instance, consume large quantities of browse in contrast to other species of quail, which feed moderately or not at all on foliage and the like.

The scaled quail is conspicuously more insectivorous than any of the others, with only the bobwhite exhibiting a similar tendency. Kelso (26), like Judd, found that the diet of the scaled quail (based on 657 stomachs and gizzards) contained a rather high proportion of animal matter, largely insects, which reached a peak of 49 per cent in June and averaged 22 per cent for all months of the years. The principal food plants on range that ran heavily to native vegetation were sophia, broomweed, lotus, morning glory, prickly pear, mesquite, vetch, and sage in that order of abundance.

Grains were of no importance. However, on range where domestic plants were available, grains like oats, kaffir corn, and wheat formed a conspicuous part of the diet. In this respect, Kelso's data contradict those published by Judd; but since Judd's work is based on a small number of stomachs, it is conceivable that most of them might have come from locations where domestic grains were not abundant. According to Kelso, stomach contents of young scaled quail contained 71 per cent animal matter, 29 per cent vegetable matter. Gravel constituted 6.26 per cent of the gross stomach contents.

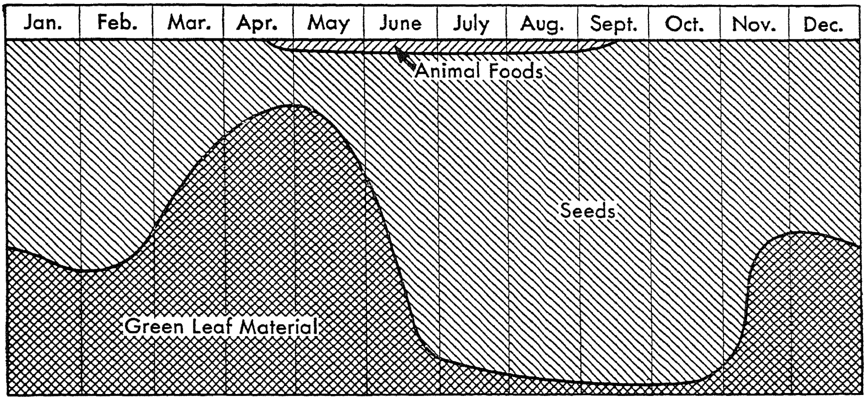

FIG. 5·3. Relative proportions of seeds, green leaves, and animal food consumed by the California quail through the year. (Sumner, 40)

The diet of Gambel quail, according to studies by Gorsuch (20), consists of vegetable and animal foods in proportions of about 9 to 1 respectively. Various legumes, especially mesquite, comprised nearly 40 per cent of the total diet, followed in order by sophia, morning glory, grasses, alfileria, cacti, four-o'clocks, mistletoe, and many other plant species of lesser importance.

Glading, Biswell, and Smith (19) found that the diet of the California quail is almost wholly of vegetable materials. The contents of 118 stomachs contained slightly more than 27 per cent green food, 72.0 per cent seeds, 0.5 per cent animal matter, and the remainder miscellaneous materials. Leaves made up the bulk of the food during January, February, and March and about 20 per cent during April and May. During the remainder of the year seeds formed the major constituent, replacing other materials entirely in some instances. The four principal food materials, comprising 52 per cent of the total, were alfileria, clover, turkey mullein, and Spanish clover. Sumner's (39, 40) work, like that of other investigators, shows the diet of this quail to be singularly low in content of animal matter, accounting for but four-tenths of 1 per cent of the total in the 102 stomachs he examined (see Fig. 5·3).

Water and Grit. It seems likely that most quail—certainly the bobwhite and Gambel quail—are not dependent upon open bodies of water for their moisture supply. Dew, succulent herbs, and fleshy fruits satisfy their requirements in this respect. However, there is no reason to believe that these birds rely wholly upon such supplies when water in the free state is available. Gorsuch (20) states that Gambel quail, although attracted to watering places, appear to come there less for the water than for the food plants which grow more abundantly on the moist sites. California quail can live without free water if succulent food is available; but when green materials disappear, water must be obtained from some other source (40).

Grit is an essential part of the diet of all quail (see Table 26). Gravel is perhaps the most satisfactory material, but hard-coated seeds and chitinous insect parts serve the same purpose (*16 g.r.*). When grit is readily available, considerable quantities of it pass regularly through the digestive tract, but at other times when suitable materials are scarce, grit may be retained in the gizzard for a week or more (35).

TABLE 26. THE OCCURRENCE OF MINERAL MATERIALS IN THE STOMACHS OF CERTAIN QUAIL

Species	Authority	No. of stomachs	Mineral content as a per cent of the total	
			Average of all stomachs	Range of monthly average
Bobwhite	Handley and Stoddard (35)	1,659	3.5	
Bobwhite	Judd (25)	918	1.0–5.0	
Gambel quail	Gorsuch (20)	178	16.0 (approx.)	10.0–25.0 (approx.)
Scaled quail	Kelso (26)	258	11.0	4.6–17.7
California quail	Sumner (39)	102	14.8	
California quail	Glading *et al.* (19)	80	17.5	

Population Density. The maximum autumn carrying capacity of the best range for bobwhite is believed by Stoddard (35) and Leopold (*66 g.r.*) to be about one bird per acre. Stoddard writes of Southeastern conditions as follows:

> Everything indicates that a maximum (November) population of one bird to the acre over areas exceeding 1,000 acres is exceptionally high under present conditions and that this is approached only on the finest and most diversified quail ground, where development on preserves is being actively carried on.

He estimates that undeveloped preserves may have one bird to 2 acres, and elsewhere, under even less favorable natural conditions, populations may only reach one to each 4 or 5 acres. Heavier concentrations are not

likely, except on small areas, and lighter concentrations are the rule (see Table 27).

Population density is constantly changing, except perhaps on the very best range. On marginal range, where many factors of decimation are operative, fluctuations are frequent and often extreme. At the same time

TABLE 27. SUMMARY OF CERTAIN STUDIES ON THE POPULATION DENSITY OF BOBWHITE RANGE

State and authority	Year	Study area, acres	Acres per bird	
			Spring	Fall
Wisconsin: Errington (11)	1930–1931	200	3.4	3.0
		3,200	13.6	12.5
		640	20.0	16.8
		640	20.6	20.0
		1,280	64.0	61.0
Iowa: Errington (11)	1934	1,500	....	10.2
Missouri: Leopold (*65 g.r.*)	1888	480	....	0.8
Bennitt and Nagel (*19 g.r.*)	1934–1935	7,500	....	4.8– 7.0
	1934–1935	4,600	....	4.1–16.0
Texas: Lay (27)	1937	4,201	....	9.0–29.0
Florida: Stoddard (35)	1925–1927	10,000	....	4.0– 5.0

the recuperative power of the decimated population is remarkably high in certain instances, especially on range that is otherwise very productive, where an occasional cold winter with heavy snow is the principal cause of mortality. This power of recovery is well demonstrated by the following data, which show the growth in population on a tract of 3,200 acres in Wisconsin following the adverse winter of 1928–1929 (11).

Date	Population		Density, acres per bird	
	December	April	December	April
1929–1930	121	112	26.4	28.5
1930–1931	257	236	12.5	13.6
1931–1932	400	290	8.0	11.0
1932–1933	406	339	7.9	9.5

In four breeding seasons the population not only trebled but apparently reached the normal carrying capacity of that particular range, which Errington estimated was about one bird to 10 acres. Leopold [1] refers to

[1] LEOPOLD, ALDO. 1945. Wildlife explorations at Prairie du Sac. *Wis. Conserv. Bul.* **10**(7–8):3–5.

this phenomenon as "inversity" and quotes Errington as follows: ". . . that since 1929 the smaller the breeding population in the spring the greater percentage of survival in the fall."

In Missouri the 1934 population at the start of the hunting season was estimated to number 3.5 to 7.4 million for the entire state, or one bird for each 6 to 12 acres (*19 g.r.*). Emlen (5) gives the population density of California valley quail on the college campus at Davis, Calif., for Jan. 1, 1937, as a bird for 7 acres. He furthermore characterizes this as a "low-density population."

MORTALITY

Mortality before Hatching. Nesting losses among quail, as with most ground-nesting birds, are likely to be high, even under favorable conditions. Stoddard (35) found from a study of 602 nests of bobwhite in the Southeast that 64 per cent were failures, and Leopold (*66 g.r.*) presents unpublished data of Errington that show a mortality of 50 per cent among 68 nests studied in the Middle West. Studholme (38) gives the percentage of successful nests in Pennsylvania as 33 per cent for 61 nests under observation.

Desertion of the nest by the female accounted for nearly one-third of the losses recorded by Stoddard, and destruction by natural enemies for most of the remainder. Human disturbances, floods, rains, drought, and other atmospheric agencies were responsible for more than half of the desertions. Among the predatory enemies of quail the eastern skunk was most destructive. Other predators contributing to the losses included dogs, cotton rats, opossum, crows, blue jays, turkeys, snakes, and ants. It appears likely that the snake and opossum are considerably more harmful than the records infer, and Stoddard believes that many of the desertions which he attributed to unknown agents were probably caused by these two predators.

During the period of laying and the first few days of incubation, the female is easily provoked to leave the nest and often deserts it completely if disturbed at this time (10). Later in the season, however, females are less sensitive and desertion is not so common. Losses of all types, whether due to desertion or destructive enemies, diminish as the season advances, owing, probably, to the more luxuriant summer vegetation, which provides better concealment. During the 1931 season in Wisconsin Errington (10) found that approximately 10 per cent of the quail eggs failed to hatch and an average of slightly less than 14 young left each nest.

Gorsuch's (20) study of the Gambel quail discloses a high degree of similarity in the nesting difficulties of this bird and the bobwhite. Losses were high, and predators of the same general character were responsible for the destruction. Of 44 nests examined, 11 were successful, 8 were deserted (man being the responsible agent in every case but one), and 25

were destroyed, principally by small rodents, including the cotton rat and the round-tailed ground squirrel. Among other predators Gorsuch mentions the house cat, which appears to destroy nests just for the pleasure of it; the skunk, which restricts its activities largely to agricultural lands; snakes and the gila monster, neither of which is plentiful. On the other hand, snakes, even though destructive, are not to be wholly condemned, for they prey upon large numbers of rodents and probably in this way save more nests than they destroy. Foxes, bobcats, and coyotes were not responsible for any significant number of nesting losses, contrary to common belief.

The California and valley quail are no more successful in avoiding nesting losses than the bobwhite or Gambel quail. Glading (18) found that 79 of the 96 nests under observation were abandoned before hatching or destroyed. Of the latter group, numbering 60 in all, 30 were destroyed by ground squirrels. House cats, coyotes, spotted skunks, cattle, bobcats, gray fox, blue jays, man, and unknown causes accounted for the remainder. In relation to ground squirrel losses, a population of 5 to 10 squirrels per acre were present on the upper portion of the hills and 20 to 25 per acre in the draws and canyons, a population considered moderately dense. On areas where poison bait was used to control the squirrels, quail increased with great rapidity and outnumbered more than two to one the birds on check areas where no control was tried (18).

Losses Due to the Elements. Weather has both a direct and indirect effect upon bobwhite populations. While the direct effects, such as winter killing, are undoubtedly important, the indirect effects—which make themselves felt through the relatively favorable or unfavorable condition of the cover and food—are equally important and exert a tremendous influence upon the success of the quail crop in any given season. When rainfall exceeds the mean, vegetation is likely to be more luxuriant and food more plentiful; when rainfall is less than normal, habitat conditions become correspondingly less favorable. Although it is probably true that torrential rains, which saturate the earth and flood low ground, cause birds to desert their nests and occasionally drown newly hatched chicks, there is little evidence to support the common belief that a wet season is less productive than a dry one. In fact, the opposite relationship appears to be the truth of the matter (10). Gerstell (15) found in Pennsylvania that a plentiful summer precipitation and a high hunting take of bobwhite are closely correlated and follow this same trend during 10 of the 12 years investigated. When the season was abnormally wet, the take was high; and when the season was dry, the take was low. Additional evidence of a similar nature is offered by Leopold and Ball (29), who state that the quail population in the Great Lakes region decreased during the drought of 1930 and suffered most where the drought was most severe.

The decimating influence of winter weather depends upon geographical locality, the severity of temperatures, the depth of snow, and the vigor of the overwintering birds. Southward, where winters are generally mild, the factors associated with climatic mortality are less lethal than elsewhere in the bobwhite range, particularly along the northern limit, where existence during the winter is precarious at any time and periodically becomes quite impossible. These are the marginal parts of the range, tension zones, so to speak, in which the population density fluctuates with the severity of winter weather and is largely controlled by it.

The lethal effects of winter are threefold: (1) intolerable low temperatures, which, even though short in duration and occurring but once in an otherwise mild winter, may cause death by freezing; (2) deep snows or sleet, which cause death by starvation if food supplies are rendered inaccessible and occasionally trap roosting birds beneath a thick crust from which they are not able to escape (34); and (3) persistently cold weather, month after month, which wears down the birds and so lowers their resistance and vitality that the weakened victims succumb from exposure or fall prey to predators (28).

It is Errington's (8) opinion that the fitness of a bird to survive the vicissitudes of winter is closely related to its weight, his assumption being that the larger, heavier individuals are stronger and more alert. For Wisconsin conditions birds weighing 180 grams (6.4 ounces) or more are capable of withstanding any ordinary winter weather. A bird of 160 grams (5.6 ounces) is strong but lacks reserve and has low recuperative power. One hundred and thirty grams (4.6 ounces) is the marginal weight; birds of this size survive some winters but not others. Birds of less than this weight, lacking the needed stamina, usually succumb before spring. These figures are probably applicable only to northern parts of the bobwhite range, but the principle is no doubt pertinent anywhere. Even fat, well-fed birds may succumb to excessively severe weather (28). As indicated in the introduction to this chapter, winter losses on the northern edge of the range may vary from almost no loss to complete annihilation (10).

Losses Caused by Predatory Birds. It is now generally accepted that a well-fed healthy quail population of a density not exceeding the carrying capacity of its range is highly resistant to predatory pressure (11). This hypothesis, which probably applies with equal aptness to all animal populations in their native state, is one of the more important contributions to recent game research. Errington *et al.* (14) found in Wisconsin that winter predation rarely exceeded 6 per cent when a population remained below the carrying capacity of its range but the proportion mounted rapidly when that limit was exceeded. Great horned owls and Cooper's hawks were the chief offenders, but more significant is the fact that predation took the same toll whether these two principal avian enemies were abundant or

entirely lacking. In other words, for a given combination of habitat conditions and population density, a certain predator loss occurred irrespective of the kinds of predators or of their numbers within limits.

Cooper's and sharp-shinned hawks are the only avian enemies of the bobwhite that warrant control measures in the Southeast (35), and Gorsuch (20) found them to be the principal predators attacking Gambel quail in Arizona. Goshawks undoubtedly prey upon bobwhite in their periodic forays into quail range, but fortunately depredations by these birds, though perhaps acute when they occur, are not frequent.

Losses Caused by Predatory Mammals. Mammalian predators are principally harmful in destroying nests and eating eggs, and in this capacity they have been discussed in a previous section. Once the eggs are hatched and the birds leave the nest, they fall prey to mammals on occasion but much less frequently than to enemies on the wing. Of the resident carnivores, foxes, weasels, and wildcats contribute to the predatory loss, but their predations appear to be largely accidental. Probably the worst mammalian enemy and one that should be dealt with summarily is the abandoned domestic cat, which is capable of killing quail in all stages of development. Gorsuch lists the feral cat and perhaps the gray fox as enemies of adult Gambel quail, and it seems probable that this relationship holds among other quail.

Losses Due to Hunting. Bennitt and Nagel (*19 g.r.*) present information on the 1934 hunting season in Missouri that is perhaps typical of good bobwhite range in the Mid-central states. They estimate that 77,000 quail hunters (50 per cent of the licensed hunters) bagged 1,171,000 bobwhites. To this figure they added another 351,000 to cover crippling losses and birds illegally taken, bringing the total kill to 1,522,000. This amounted to one quail to about 29 acres for the entire state and reduced the estimated fall population by half. Of each 100 birds alive at the start of hunting, they believe that 40 may be killed in normal years without depleting the growing stock below the level needed to restock the range the following season. Of this number, 4 will be killed illegally and 8 will be shot but not bagged, leaving 28 for the hunter.

The annual hunting take in Pennsylvania for the years 1923–1934 ranged from about 92,000 to 194,000, averaging 134,000 per year for the period. This amounted to one bird for each 214 acres (16). For Pennsylvania's better quail range, the kill amounts to one bird for approximately 100 acres. Stoddard and Komarek (37) estimate that the hunting take may be one bird for 10 acres for good quail range in the Southeast.

Crippling loss is likely to account for a sizable proportion of the annual kill, and by comparison with similar losses among many other game birds it is apt to rank high. Being smaller than most game birds, the quail is

less easily found when shot. Also it possesses less strength and reserve with which to recuperate from its wounds.

Data compiled by Errington and Bennett (13) from information furnished by Missouri hunters indicate that the crippling loss is about 18 per cent of the total kill. The loss varies greatly among different hunters and depends to a large extent upon whether or not dogs were used. Hunters shooting over good dogs lose an estimated 4 per cent of their birds, whereas hunters with the average dog lose 16 per cent.

Survival figures for quail and fall population composition have been determined for a number of localities in the quail range. Emlen (6) gives the survival expectancy for California valley quail as follows:

Survival	Per Cent
From egg to end of 12 months	8.5
From November to following November	31.0
All birds from May to the following May	50.0
All birds 18 months old from November to November	50.0

Errington (12) in a 15-year summary of the success of breeding bobwhites at Prairie du Sac, Wis., gives the expected success of the breeding season at different population levels:

No. of pairs in spring	Average survival of young per pair	Total fall population
20	5	140
50	4	300
100	2	400
170	−1	440

Age-composition data for a number of localities have been determined by an analysis of the wing feathers from legally shot birds [for this method see A. Starker Leopold (30)]. Although age-composition figures do not indicate the factors responsible for the losses, nevertheless they do show the game manager what part of the breeding stock and reproduction may be expected to survive to the hunting season.

TABLE 28. AGE-COMPOSITION DATA FOR QUAIL IN VARIOUS LOCALITIES DURING THE HUNTING SEASON

Location	Investigator	Per cent of population	
		Adults	Juveniles
Iowa	Hendrickson (23)	21.0	79.0
Missouri	Leopold (30)	17.6–25.4	74.6–82.4
California	Emlen (6)	33.0	67.0

MANAGEMENT

Census. The *complete census* is perhaps the most reliable inventory method for quail. By this method each covey on the range is flushed and the birds counted. One man, if experienced and familiar with the territory, can carry out the operation with satisfactory results, but several men speed up the process and are likely to attain greater accuracy. The use of trained bird dogs is another variation of the method that has merit. For a more detailed discussion of the complete census method the reader is referred to Chap. IV, *Pheasants*.

In regions where snow blankets the ground in winter, populations can be enumerated with fair accuracy by *counting tracks*. If the census enumerator locates the trail of each covey, he is usually able to determine the number of birds it contains through careful examination of the tracks. However, complications are likely to be encountered. After a heavy snow, well-fed coveys not infrequently remain in one place and move about but little or not at all for a day or so; and when they finally leave their shelter, there is always the possibility that part of the covey has strayed away or traversed the trail more than once in their wanderings.

Counts of whistling birds provide a rough measure of population density, but this procedure is likely to be less accurate than other methods. During the winter the birds of a covey, both male and female, frequently whistle back and forth in the early morning. If an observer is so situated that he is able to place the individual calls, he can estimate the size of the covey within reasonable limits of error.

This same technique, somewhat modified in its application, can be used during the spring breeding season. At that time the winter coveys have dispersed and most of the birds have found mates. Usually, however, the females are outnumbered by the males. When the hens have all been claimed by the more fortunate of the cocks, those males unsuccessful in their suit roam about the range whistling to the mate that seldom appears. When the number of such unmated males and the sex ratio are both known, the total population is easily computed. For example, suppose the number of unmated cocks on a range is 50 and the sex ratio is 55 males to 45 females; in this case there are 10 unmated birds in each 100, and the total population is therefore 500, *i.e.*, $[50/(55-45)] \times 100$. Since this method is predicated on the assumption that the sex ratio favors the males, that all the females find mates, that the unmated males all whistle, and that the unmated females do not, there are several possible contingencies which may invalidate results, entirely aside from errors incurred by an inaccurate count of whistling birds or a mistaken determination of the sex ratio. At best this method seems unlikely to give more than a rough approximation of the number of quail on the range.

Food and Cover Development. The successful propagation of quail in their natural habitat depends upon the development of a diversified cover, which for best results should contain cropland, grassland, brushland, and woodland in about equal proportions and well distributed in small units. Diversification effects a more nearly uniform distribution of coveys, discourages wandering, and improves productivity. Where diversification is lacking, the birds tend to migrate locally to more attractive habitat elsewhere. Diversification can be effected in a number of ways, the more

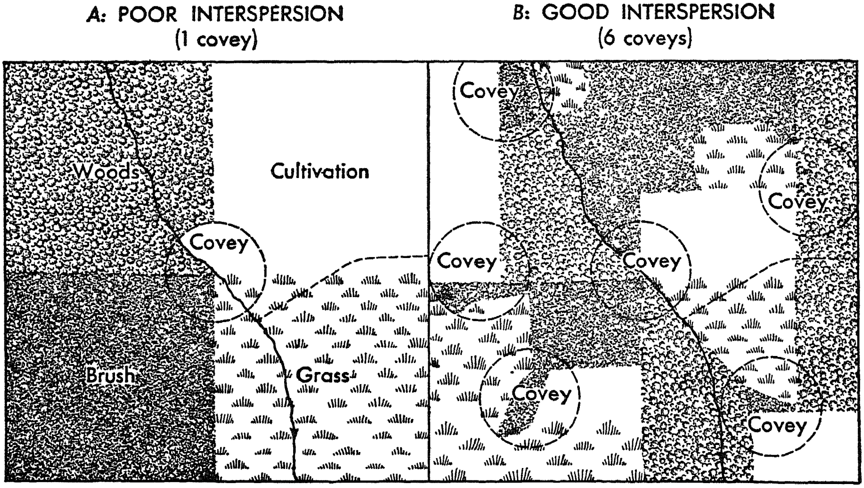

FIG. 5·4. A method of quail management. Management involves increasing game on range already occupied or changing unoccupied range so it is habitable. In this case the management consists of changing the diversification of the cover types. (*From Aldo Leopold, "Game Management," Charles Scribner's Sons, New York.*)

important of which are considered in the recommendations that follow (see Fig. 5·4 for results of diversification and interspersion). These necessarily treat the subject in an extensive manner, for each case differs and the problem varies with locality.

Extensive areas of cropland in large continuous units can be greatly improved as a quail habitat by the development *of cover lanes*, or strips that traverse the tract at intervals. These lanes encourage the quail to make use of range previously avoided because proper approach and escape cover were lacking. In a habitat of this nature suitable cover is sparse and often widely scattered in small islands entirely isolated from similar units. Here the problem is one of providing safe avenues of travel along which the birds can move from one cover unit to another or to spots in the adjacent fields or cropland where food is plentiful.

Fence rows afford fine sites for developing travel lanes, because cover located there occupies the minimum amount of land useful for other pur-

poses. When fence rows are lacking or insufficiently numerous, cover strips should be located where they will least interfere with the agricultural program. When this alternative is resorted to, a certain amount of agricultural land must be sacrificed, but it need not be large.

Frequently the terrain and soil are such that the reserved strips can be placed where they follow natural draws or utilize ground of low productivity. Stoddard (35) recommends strips 40 to 50 feet wide situated at intervals of 100 yards or so, but narrower strips, though less desirable, possess high value. Twenty feet is about the minimum useful width.

On preserves or other tracts where the immediate establishment of such cover is more important than the smaller expense of getting it naturally, the planting of woody perennials adapted to the region must be resorted to. Elsewhere, volunteer growth of native vegetation such as the cherries, brambles, sumac, and similar plants can be relied upon to provide a suitable cover that requires a few years to attain its best development but once established compares favorably with planted coverts.

Eroding gullies and draws, if planted to soil-holding plants like black locust, wild plum, and snowberry, form excellent cover of a relatively permanent nature. The usefulness of such developments for year-round occupation is further enhanced if food patches are planted about their margins. This method has been employed with considerable success in parts of the South and is highly recommended by Stoddard (35). Natural thickets and other small areas of brushland poorly adapted to agriculture can be similarly handled, except that planting of cover species is rarely necessary because suitable natural vegetation is abundant or soon develops if encouraged.

In regions where *uncontrolled grazing* is permitted in open woodlands and brushland, quail range suffers accordingly, because the grazing animals destroy cover, eat food plants, and trample nests. Wherever possible, grazing should be confined within fenced areas if quail are to attain maximum productivity (35). Within the pastured area thus set off, quail are not likely to prosper, although conditions can be improved within limits by the development of thickets and cover lanes containing plants that livestock rarely graze, like wild plum, hawthorn, prickly ash, and greenbrier.

Woodland is frequented by bobwhites mainly in the winter, and then only when the overhead canopy is sufficiently open to allow the presence of cover and food plants in abundance. Cutting operations, whether harvest or intermediate cuttings, tend to improve conditions for quail tenancy; but in forests grown primarily for the production of timber crops, improvements of this character are not likely to be permanent or particularly stimulating, except perhaps in the pine lands of the Southeast where the stocking is less dense. In that region open woodland often makes fine range, particularly during the period when pine and oak mast is plentiful.

a

b

Fig. 5·5*a* and *b*. Soil conservation helps both the farm owner and wildlife. Corn and small grains have been planted in contour strips along the woods. Pasture animals have been kept off the land in the foreground. The results are a stabilized soil and good distribution of both food and cover for wildlife. (*Soil Conservation Service.*)

The use of broadcast burning under controlled conditions as a means of removing unwanted ground cover and surface litter is a management technique peculiar to the Southeast, where certain vegetative cover types [1] not only permit the use of fire in this manner but apparently require it if quail range is to be kept productive (35, 36). Along the coastal plains of that region, much of the typical quail country lies in open stands of pine woodland having a thick ground cover of needles and an understory of herbaceous plants such as broom sedge (*Andropogon* spp.) and other rank-growing grasses. This "rough" of needles and understory vegetation frequently accumulates to such depth and density that food-bearing plants of the kinds essential to the production of quail are seriously held in check and in extreme cases are prevented from growing altogether. On worn-out agricultural land, abandoned to nature, a similar condition is likely to develop during the broom sedge stage, which usually occurs in the course of natural succession. Cover of this composition discourages quail tenancy, if for no other reason than its great density; it also attracts large numbers of cotton rats, which find it a favorable habitat. These pests feed upon eggs of the nesting quail and in turn attract other predators which, like the rats, prey on quail. Furthermore, the danger of fire on lands supporting broom sedge and pine "rough" is an ever-present menace, which threatens wildlife and trees alike. From any viewpoint this accumulation of herbaceous growth and vegetable debris is an undesirable element that requires treatment in the Southeast if quail are to thrive.

Of the several ways in which too much cover can be reduced, periodic removal by controlled broadcast burning is the most economical. By "controlled" burning is meant the use of fire under conditions of weather, vegetation, and supervisory organization that permit a good clean burn of the unwanted ground cover without undue damage to other vegetation that requires protection, for instance, forest trees. Night burning, when heavy dew lies upon the ground and the air is quiet, is the ideal procedure. If areas to be treated are so extensive as to necessitate burning during the day, greater precautions must be exercised to hold the fire in check. The best time for day burning is the period immediately following a prolonged rain or a heavy shower. As soon as the moist materials have dried sufficiently to be combustible, burning should commence. Dry days, with low relative humidity and vigorous air movement, present the worst possible conditions for controlled broadcast burning.

Late winter or early spring is the season for this type of treatment. Burning at this time removes the rough and stimulates the germination of seed and the sprouting of perennial rootstocks. Where the ground being treated is expected to produce Japan clover, treatment must be completed

[1] For a more detailed discussion of the role of fire in the land-management practices of the longleaf pine forests of the region, the reader is referred to Wahlenberg (*96 g.r.*).

before germination of the clover begins, which may be as early as February. Where partridge pea is abundant, early burning stimulates germination, but the tender shoots run the danger of being frozen back. Late burning after germination has begun is equally lethal. For other food plants, especially the native legumes, timing presents a less delicate problem. Green shoots, even though killed, soon sprout again.

The frequency with which burning must be repeated is determined by the amount of rough and whether the treated vegetation is used solely for quail production or other purposes as well. When rough accumulates rapidly and other forms of land use demand no special consideration, annual burning is often necessary; an interval of 2 or 3 years between burning represents about the maximum for best results. If forestry is practiced on the same range, a somewhat longer interval is more desirable from the viewpoint of safeguarding the trees; and at certain periods in the development of the forest stand, notably during the seedling and small sapling stages, fire must be excluded completely. In stands of longleaf pine, however, modification of this schedule is permissible. Because of its remarkable resistance to fire, this species requires complete protection only during the first year or two after germination and again for a short period of years during the time of initial height growth and the development of thick bark, which lasts roughly from the seventh to the fifteenth year after the seedling first takes root. At other times light burning of the kind just described can be undertaken without serious injury to this tree. In fact, longleaf pine is ideally adapted to a program combining quail production with timber production.

Where controlled burning is conducted over extensive areas, it is good practice to subdivide the tract into blocks separated by fire lanes. Tractor-drawn plows are excellent for this purpose. Once such a system is set up, burning is subject to greater control, and the treatment of individual blocks can be rotated in any way that seems desirable. Each block forms a unit that can be handled independently.

Food patches established near cover and the reservation of strips in grainfields have been used successfully in all parts of the bobwhite range as a means of maintaining populations over winter. Corn, wheat, rye, oats, buckwheat, soybeans, the various sorghums and millets, kaffir corn, milo maize, and Japan clover are all suitable for this purpose. Stoddard (35) mentions several additional plants that have been used in the South: Australian winter pea, cowpeas, vetch, Florida beggarweed, rattlebox, benne, upland rice, Johnson grass, peanut, and chufa.

Croplands can be made more productive of quail foods if cultivation is dispensed with after midsummer and stubble is left unplowed through the winter, thereby encouraging the growth of plants like pigweed, smartweed, and foxtail. Since quail are not inclined to venture far from cover, this

modification of usual farming practice is most beneficial near the edges of the cropped area adjacent to fence rows or other cover and need not be resorted to elsewhere. If corn is left standing through the winter, cover conditions are greatly improved for birds that come to feed on waste grain and weed seeds.

As a concluding statement in this section it may be well to point out that modern methods of agriculture advocating clean fence rows, the eradication of thickets and other natural cover, and the strict control of weeds hold quail populations in check and afford but little range of a desirable type. Quail can be produced in maximum numbers only on land handled by less intensive methods, which disregard some of the refinements so strongly recommended by agricultural schools and other farm agencies. Clean farming may or may not be a good farming practice, but it definitely discourages wildlife. Quail were undoubtedly most numerous in the days when lands were cultivated by more primitive methods. This discussion is not meant as a criticism of modern agriculture in any respect but one—the evolution toward clean farming, which really may not be good farming and certainly is not good wildlife management.

Predator Control. Control measures should be directed principally toward reducing the number of Cooper's and sharp-shinned hawks, great horned owls, skunks where they are particularly troublesome, cotton rats, and ground squirrels. The three winged predators often are destructive wherever they occur and may require control if highly productive conditions are to be maintained. Other hawks and owls, however, though occasionally predaceous, more than offset their destructive effects by preying upon snakes and rodents.

The cotton rat, which is particularly destructive in the South, can be controlled by burning and the use of poison (35). These animals are most numerous in dense broom sedge, and the controlled burning or plowing of such areas every third or fourth year assists greatly in holding them in check. Poisoned bait also has proved efficacious. A number of materials have been tried, but barley treated with strychnine has been found to be the most effective. Small birds eat this grain less frequently than other grains, while the rats are unable to remove the hull, which retains most of the poison.

The following instructions are taken from Stoddard (35) who quotes Silver of the U.S. Biological Survey:

Preparation of the bait. Mix 1 tablespoon of gloss starch in ¼ cup of cold water, and stir into ¾ pint of boiling water to make a clear starch paste. Mix 1 ounce of powdered strychnine (alkaloid) with 1 ounce of baking soda, and stir into the starch paste to a smooth, creamy mass, free of lumps. Stir in 1 pint of heavy corn sirup and 1 tablespoon of glycerin. Pour this mixture over 20 quarts of good quality, clean whole barley, and stir thoroughly to coat each kernel. Spread out on newspaper to dry.

Placing poisoned baits. Locate cotton rat runs, and place a medium-sized handful of poisoned barley at any point along them. Scatter the bait for a foot or more along the trail to avoid the danger of livestock picking up a toxic dose. Place a bait every 10 to 20 paces along a continuous system of runs and closer where the infestation is unusually heavy. Twenty quarts of poisoned barley should make 1,000 baits.

Poisoned bait has been used successfully by Glading (18) to control the several ground squirrels so destructive of quail nests in the West. Range baited with poisoned barley showed a sharp decline in squirrels and a rapid rise in quail.

Locally, certain other predators may require control, but such animals are less destructive in the main than those already discussed. Stoddard (35) speaks of measures to control opossum, raccoons, weasels, mink, wildcats, foxes, house cats, cur dogs, and snakes. The control of ants, a desirable objective, he dismisses as an insurmountable problem. For snakes he suggests a small-bore shot gun and the offering of bounties.

Miscellaneous Management Procedures. The *artificial stocking* of quail range is a widely practiced procedure. Where overwintering populations have been seriously depleted, this method may be the only way to build up a satisfactory crop for the fall hunting season. At other times when quail have wintered well and the spring breeding population is adequate, the release of artificially reared birds is money wasted.

Gerstell (17) believes that the release of adult birds in the spring prior to mating is more advisable than the freeing of juvenile birds in late summer or early fall. Stoddard has used the rather unusual technique of placing newly hatched chicks in the care of unmated cocks trapped a short time previously. Two or three weeks later, when the chicks have developed a few protecting feathers, the cock with his adopted brood is released on a favorable site where conditions of cover and food are suitable.

The *trapping* of quail is a relatively easy matter. Box traps, baited inside and out with shelled corn and placed on quail range, are usually effective. Several birds may be captured in one trap; and occasionally if three or four have found the entrance, the entire covey may follow. As a precaution against injury to the entrapped birds which frequently fly upward against the wire mesh, fish netting should be stretched across the trap on the inside several inches below the top.

Stoddard (35) has devised a trap that operates on a different principle. This unusual contraption contains five compartments, one in the center to hold a live female decoy and four round the outside to trap unmated cocks that attempt to reach the hen.

For *transferring quail*, Haverstick (22) recommends a small crate about 10 by 10 by 20 inches, having a top, bottom, and center partitions of wood. Several birds can be carried in one crate, the males on one side, the

females on the other. For *releasing birds* in the field, he suggests using an ordinary pasteboard shoe box, one end of which has the corners cut down in such a way that it opens outward like a flap. The birds to be released are placed in the box (each box will hold two birds conveniently), and the top is tied down. The flap at the end, caught at the top under the cover, remains closed. To release the birds, the box is set on the ground and the top loosened enough to free the end flap. The birds inside soon find the opening and work their way through it. If the operator merely removed the cover and allowed the birds to fly out, in their fright they might become separated, which is undesirable if mated pairs are freed, or they might disperse to other range. This way they *walk* from the box into their new home with no persons about to frighten them.

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G. Woods
8-28-38

CHAPTER VI

TREE SQUIRRELS

WESTERN FOX SQUIRREL (*Sciurus niger subspp.*)[1]

Geographical Distribution

During the period of early settlement in the United States, squirrel hunting was universal among the pioneers of the Ohio and Mississippi valleys. Gray and black squirrels were found in the hardwood forests to the east, and fox squirrels at first in the scattered woods of the prairie farther to the west and later in the wood lots and along the streams as farms were hewn from the dense forests.

In the summer, squirrel hunting was indulged in when farm work permitted and in the fall competed with the tasks of cutting corn and digging potatoes. It was often necessary to hunt this animal along the edge of the forest to protect the crops from hordes of hungry squirrels. Likewise, fried squirrel supplemented the menu of the settlers between the "roasting-ear period" and "butchering time."

As forest land was converted to farms, squirrel hunting became a favorite outdoor sport rather than a necessary protective occupation. At present large numbers of hunters in the Lake states and regions to the south hunt both fox and gray squirrels for sport.

The geographical distribution of the western fox squirrel, *Sciurus niger rufiventer* (Geoffroy), is shown on the accompanying range map in Fig. 6·1. This subspecies is the principal representative of the genus and forms the basis of the discussion that follows. Several other subspecies occur in the East and Middle West, but none is so widespread or important as *S. n. rufiventer*. Of these other squirrels, the southern fox squirrel, *S. n. niger* Linnaeus, is an important subspecies occurring in Florida and other Southern states. Referring again to the western fox squirrel, it will be noted from the range map that its present distribution is more extensive than formerly. The extension of the range northward, eastward, and westward is attributable to the changed conditions arising from the introduction of agriculture. Extension eastward and northward followed partial clearing of forest land, an operation that created the openings and diversi-

[1] The author is indebted to L. L. Baumgartner, formerly of the Ohio Cooperative Wildlife Research Station, and Durward Allen of the Michigan Conservation Department, for providing material concerning the fox squirrel. Unless otherwise indicated facts and specific information that follow are from these sources.

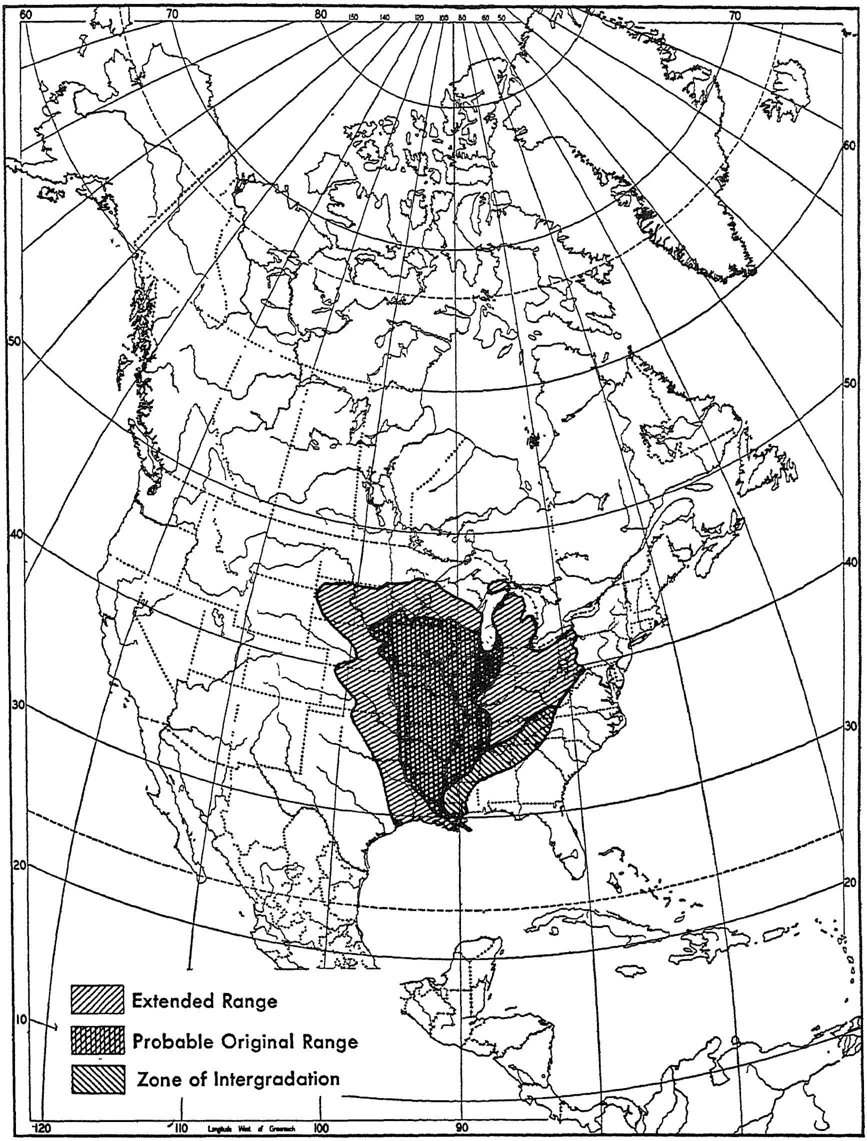

FIG. 6 · 1. Range of the western fox squirrel. (*From Baumgartner*, 8)

fied cover required by this squirrel, and settlement westward extended the range in that direction in response to the planting of windbreaks and other wooded cover. The zone of intergradation on the southeast marks that part of the range where the western and southern fox squirrels intermingle. In Texas, according to Baker (15), both gray and fox squirrels are found in

the same woods but the latter inhabits the timber along the smaller creeks and the uplands.

Life History and Ecology

The fox squirrel is one of our larger tree-climbing rodents and yet one of the most agile and cunning, relying to a great extent upon these attributes in eluding hunters and its natural enemies. According to Allen (2) the average weight of an adult male fox squirrel is 1 pound 10.8 ounces and of females, 1 pound 11.2 ounces. Seton (*88 g.r.*) speaks of a female weighing 2 pounds 4 ounces, and Allen (2) lists a specimen, no sex given, as weighing 2 pounds 11.5 ounces. These squirrels are heaviest in the fall and winter months, the females being heaviest in December to February and September to November, while the males are heaviest in the fall.

Breeding Characteristics. *Sex ratio* appears to fluctuate depending on the locality and the particular year involved. Baumgartner found that 52.5 per cent of 664 individuals which he inspected in Ohio were males. In this connection the hunting records in Ohio show more males than females taken (4). Illinois fox squirrels also show a preponderance of males (10). Allen (2) found that 55.5 per cent of a total of 728 squirrels handled were males. Trapping records sometimes show a greater number of males and sometimes more females (2). Sex ratios of litters show similar variations. Allen (2) believes that more females are produced when the population trend is upward.

Mating takes place during two periods of breeding, one in winter, the other in late spring and early summer. In Ohio, Michigan, and Illinois December and January mark the height of winter mating activities and May and June of the second mating period (2, 9, 10). To Allen (2) goes the credit for working out the complicated breeding behavior of fox squirrels, which is characterized by three different groups and three kinds of breeding behavior. The winter population in Michigan is composed of three age groups: old individuals, 2 years or more of age; spring yearlings, born during the early crop of the previous year; and summer yearlings. Mature females usually produce two litters; spring yearlings bear one litter, an early one; and summer yearlings likewise one litter, a late one. The period required for gestation is not accurately known but is probably about 45 days (2, 10). Young are born from mid-February to mid-April and from late June to early October. One female may bear two litters a year as indicated above. When a female produces two litters one season, she may not produce any the next if food conditions are bad. The number of young at birth is variable, ranging from one to five. A litter of three occurs most commonly (2). Both Baumgartner (9) and Allen (2) found the average to be slightly more than three young per litter. Average litters in Illinois vary from 2.51 to 3.70 per litter (10).

Rearing the young is a responsibility solely of the female. The male occupies the same nest during the mating and gestation periods but leaves or is driven out when the litter is born. The young, hairless at birth, are cared for during a relatively short period of about a month and thereafter must shift for themselves. Although nothing resembling a family tie is maintained beyond the period of lactation, offspring from the same litter may remain in the general vicinity such as a wood lot until the beginning of fall dispersal.

Nests are of two types: the external nest, built mostly of leaves collected together in the crotch or forked branches of a tree, and the den, located in the cavity of a hollow trunk or large limb. The former is a loose mass of leaves and occasional twigs interlaced in such a manner as to make an enclosed retreat more or less spherical in shape and approximately 12 inches in diameter, though of variable size. Dens are fashioned from almost any cavity that is large enough inside and has an entrance measuring between 3 and 3.5 inches across. Cavities with larger or smaller openings are less suitable. A depth of 2 feet or slightly more from the point of entrance to the bottom of the cavity appears to be most preferred. The average cross-section dimension of dens measures about 6 or 7 inches. Location in the tree may be high or low. Baumgartner found none below 11 feet or above 62, while the average was 36 feet. Oak trees are more used for nesting than other tree species, followed in order of preference by elm, beech, sugar maple, sour gum, and hickory (7).

Nest-building activity is most evident in May and June and again in September and October. Both old nests and dens may be repaired and occupied season after season, especially dens, but often not by the same squirrels. Nests serve a threefold purpose: as a place to rear young, as havens of escape, and as retreats for resting. Nests higher up seem to be occupied more commonly by mature females. Males and immature females tend to or are compelled to use nests nearer the ground.

Movements. The fox squirrel, though an active animal, restricts its daily movements to relatively short distances. Its seasonal movements are also short except during the breeding period and where population pressure is great. Under normal circumstances the daily cruising radii for seasons other than the mating period are not likely to exceed 700 to 800 feet, averaging 400 feet. Baumgartner (9) believes that an individual squirrel spends most of its time during the course of a day on not more than 2 to 3 acres. Allen (2) gives the area used in any one season as 10 acres and 40 acres or more as the size of the yearly home range. These animals for the most part are inhabitants of farm wood lots and less so of extensive forest tracts. Consequently they are strongly influenced in their activity by limitations of the particular wooded area they occupy. The larger the wood lot the greater is likely to be their cruising radius. These squirrels

are active only by day (*13 g.r.*) and do not leave the shelter of trees except to feed on grains in adjacent fields. In winter they may become quite inactive but do not hibernate.

During the mating seasons greater than normal activity occurs and also at times when population density becomes excessive. During December and January and again in May and June adult male squirrels cover greater distances than usual, apparently in search of mates. Tagged individuals have been known to travel nearly 2 miles on these treks, but the average is doubtless considerably shorter. In late summer and early fall there is ordinarily a fairly marked readjustment of the population level, as evidenced by a gradual dispersal of squirrels on heavily populated range to localities where density is lower. Travel during this period often covers several miles, with maximum distances reported as 40 and 46 miles from the place of birth or liberation (2, 3). Dispersal takes place mostly between wood lots by way of thickets along roadsides, stream banks, and fence rows.

Cover Requirements. The characteristic habitat of the fox squirrel is mature hardwoods or pine-hardwoods composed of mast-bearing species. Cover in which small trees, tree reproduction, or shrubs predominate is little frequented except as an avenue of travel to more suitable types elsewhere. Northward, the favored type of woodland is a mixture of oak and hickory. A pure oak stand is perhaps the ideal, but pure hickory is regarded only as good winter range.

Stands of beech, maple, and associated hardwoods such as ash and basswood, though habitable, produce too little mast to support a heavy population. Unless fairly extensive in area or during heavy beech-seed years, which are of infrequent occurrence, stands of this tree species are likely to serve only as temporary habitats. Southward, suitable environment is provided by oak-hickory stands and by mixtures of these tree genera with various species of southern pines, all of which produce mast in abundance.

Throughout most of its present range the fox squirrel is found in rural agricultural districts on farm wood lots bordered by cleared land. In its original range it was limited to the transition zone between the true prairie, where wooded growth was nowhere extensive, and the true forest, where grassland occurred not at all or but sparingly. Why unbroken forest land is less habitable than forests interspersed with grassland is not clearly evident; but whatever the reason, interspersion of this nature seems to be an essential element of the fox squirrel range. A wood lot of about 10 acres is near optimum with respect to size. Preferably it should be connected with neighboring wood lots by cover lanes, such as hedges or thickets along fence rows, to facilitate ease of travel from one lot to another. Stands of 1 or 2 acres usually are too small for year-round occupancy unless natural food supplies are supplemented from other sources such as grain in near-by fields. Ordinarily, stands of small acreage serve only as temporary cover

(2). Only 12 per cent of 2,800 Ohio wood lots rated as to suitability for squirrel habitation were regarded as better than fair, and nearly 50 per cent were considered poor (9).

Food. The food of fox squirrels is primarily of vegetable origin. Animal foods, consisting mostly of insects, both adults and larvae, may be consumed with some consistency but in bulk comprise a very minor portion of the total diet intake. The staple diet consists of mast principally and

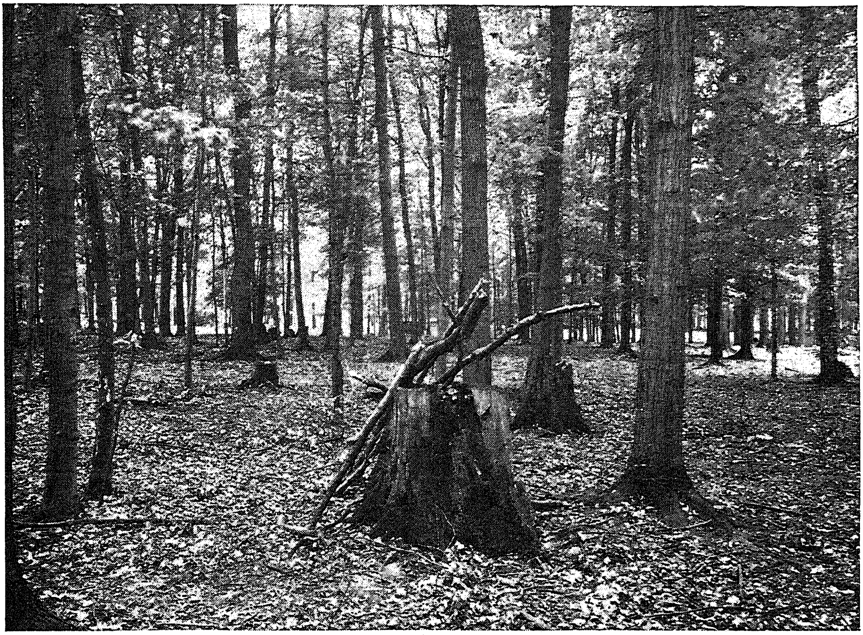

FIG. 6 · 2. Farm wood lot in Geauga County, Ohio. The parklike condition is due to pasturing the wood lot. Mature trees furnish mast for squirrels and are more likely to contain den cavities than are younger trees. This wood lot would be more useful for cottontails, bobwhite, and pheasants if grazing was controlled and the understory allowed to develop. (*U.S. Soil Conservation Service.*)

corn where available. Favored mast-producing species are oaks, hickories, black walnut, butternut, beech, pines, and possibly buckeye. These materials are gathered and stored in season and drawn upon later when the nut supply on trees is exhausted (11). Emergency foods, turned to when mast is no longer procurable, include seeds and buds of maple and elm, buds of oak and aspen, seeds of tulip poplar, catkins of willow, and the fruit of Osage orange (14). None of these materials are especially palatable but appear to be digestible and sufficiently nutritious to sustain life. There are also certain other foods that may be regarded as serving an auxiliary capacity, supplemental to the staple diet of mast, and are eaten in small

TABLE 29. VEGETABLE FOODS OF THE FOX SQUIRREL IN OHIO (6)

Food	Class *	Palatability	Seasonal availability			
			Spring	Summer	Fall	Winter
Hickory nuts	*S*	10	x	x	x	x
Acorns	*S*	10	x	x	x	x
Beechnuts	*S*	10	.	x	x	x
Corn	*S*	10	..	x	x	x
Black walnuts	*S*	8	x	x	x	x
Butternuts	*S*	3	..	.	x	x
Buckeye nuts	*SE*	6	.	.	x	x
Maple seeds and buds	*E*	10	x	x	x	
Elm seeds and buds	*E*	10	x			
Willow catkins	*E*	3	x			
Aspen buds	*E*	3	x			
Oak buds	*E*	3	x			
Hackberry fruit	*SEA*	2	..	.	x	x
Soybeans	*AE*	5	..	..	x	x
Tulip poplar seeds	*AE*	4	..	x		
Osage orange fruit	*AE*	3	..	.	..	x
Hazelnuts	*SA*	8	..	.	x	
Wheat seeds	*A*	8	..	x		
Mulberry fruit	*A*	8	.	x		
Witch hazel fruit	*A*	7	.	..	x	
Sour gum fruit	*A*	7	..	x		
Dogwood fruit	*A*	6	.	.	x	x
Blackberry fruit	*A*	5	.	x	x	
Wild grapes	*A*	4	.	x	x	
Apples (fruit)	*A*	4	.	x	x	
Huckleberry fruit	*A*	4	..	x		
Hop hornbean seeds	*A*	3	..	.	x	x
Raspberry fruit	*A*	3	..	x		
Fungi	*A*	3	..	x	x	
Bittersweet fruit	*A*	2	..	.	x	x
Sycamore seeds	*A*	2	x	.	.	x
Black cherry fruit	*A*	2	..	x		
Blueberry fruit	*A*	2	..	x		
Green leaves	*A*	2	x	x		
Greenbrier fruit	*A*	2	..	x		
Blue beech seeds	*A*	1	..	..	x	x
Wahoo fruit	*A*	1	..	..	x	
Sedge weeds	*A*	1	..	x		
Knotweed seeds	*A*	1	..	x		
Oats	*A*	1	.	x		

* *S* denotes staple foods; *E*, emergency foods; *A*, auxiliary foods.

amounts at all seasons when available. Important in this class are wheat, soybeans, hazelnuts, and the seeds or fruit of witch hazel, mulberry, sour gum, dogwood, blackberry, tulip poplar, and grape. In some cases the line of demarcation between these three classes of foods is not always distinct, and certain foods may fall in one class or another depending upon seasonal and geographical variations in abundance.

Table 29 on food palatability and availability for Ohio is probably representative of the northern part of the fox squirrel range.

Allen (2) emphasizes two main conditions in relation to fox squirrel food. (1) With an abundance of good-quality food in the fall squirrels are able to become very fat and protect themselves from food shortage during the winter. Well-nourished squirrels thus are able to maintain a favorable physiological condition during the winter breeding season. (2) The second important item in relation to food is the location of food-producing trees. Mast-producing trees that grow in the open are more likely to have large spreading crowns which yield a greater quantity of food than trees growing in competition with other trees.

Water and Mineral Requirements. Such minerals as are not secured from the normal food supply are obtained from the bones of dead animals and from particles of soil, both of which appear to be eaten deliberately. Bones are sufficiently numerous in most woodland to provide all the calcium that is required. Squirrels drink freely from streams, springs, and small pools but may subsist where water in the free state is not present. Baumgartner (6) reports that heavy squirrel populations are supported by ranges without water.

Population Density. The population level among fox squirrels is subject to marked fluctuations which are of two types: (1) cyclic fluctuations due to forces as yet not wholly understood and (2) fluctuations within the normal cycle caused by variations in the volume of available food. The cyclic changes appear to follow a cycle of 4½ to 6 years according to Baumgartner, although the normal rhythm of this cycle may be interrupted by factors related to the food supply. Periodic scarcity of staple materials accentuates the downward trend of the cycle and also tends to counteract its upward swing. Owing to the lack of regularity in the seed-bearing habits of mast-producing trees, there is no way accurately to predict the occurrence of shortages of this class of food materials. Oaks and hickories ordinarily bear some seed almost every year and bumper crops every 2 to 4 years. Beech, on the other hand, has a heavy seed year at highly irregular intervals, often as long as 7 years, which accounts probably for the lower productive capacity for squirrels of beech-maple stands in contrast to woodlands consisting of oak-hickory mixtures.

The complex nature of the fox squirrel habitat is such as to make it difficult to know how much of these various components to include as

area actually occupied by this animal. For example, a field of corn adjacent to a wood lot may reduce the size of the wooded habitat but still may not be included in the density evaluations. Table 30 gives a summary of squirrel density in Ohio wood lots.

TABLE 30. POPULATION DENSITY OF FOX SQUIRRELS ON FARM WOOD LOTS IN OHIO (5)

Year	No. of wood lots	No. of of acres	No. of squirrels	Squirrels per 100 acres	Acres per squirrel
1935	1	88	120	136	0.73
1936	4	162	183	113	0.88
1937	10	352	203	58	1.73
1938	9	333	222	67	1.50
1939	6	282	145	51	1.96

Without question, the above figures are representative of the more desirable locations. Allen (1) in a study of a fox squirrel habitat of second-growth oak in Allegan County, Michigan, estimates 40 acres carried a late-winter population of 8 squirrels, or 1 squirrel for each 5 to 6 acres, and a fall population of 10 to 13 squirrels, or 1 squirrel for each 3 to 4 acres.

Allen (2) reports that densities of fox squirrel population depend on time of year, type of woodland, and the breeding success of the particular year during which studies have been made. He indicates that maximum numbers probably occur in the fall of the year following favorable years for mast production in oak-hickory wood lots in the prairie wood lot type of habitat. In such locations food-producing crops are usually raised in fields surrounding the wood lot. Two squirrels per wooded acre over an area as large as a township (23,040 acres) are about maximum. This is similar to the squirrel population density reported for black-oak stands in Illinois (10). In desirable woodlands of small size it may be possible to find four or more squirrels per acre during good years. Under normal conditions spring breeding populations usually are about one-third of the fall population.

Mortality

Losses Due to the Elements, Predation, and Miscellaneous Causes. Despite its small size the fox squirrel is unusually durable and less subject to certain types of mortality than one might at first suspect. Its thick fur provides a warm coat against the rigors of winter, and its habit of retiring to a nest or den during cold weather affords added protection. Because the fox squirrel is primarily arboreal in habit, it is, at least in part, not subjected to many of the dangers that beset ground-inhabiting animals. Its principal predatory enemies, therefore, are probably avian. Baum-

gartner (9) regards both the red-tailed and Cooper's hawk as important enemies. The great horned owl, though occurring in the same habitat, is not especially harmful. The nocturnal nature of this owl as opposed to the diurnal habit of the squirrel eliminates any but a chance meeting during early morning or twilight hours. The fox is probably the most destructive of the mammalian predators. The quantity of squirrel remains found in fox dens suggests that loss from this cause may be considerable. Dogs and cats account for some of the fox squirrel loss, but the extent of their predation is unknown. Weasels, though capable of climbing trees, were not observed by Baumgartner to do so for the purpose of pursuing squirrels. Nor did he detect evidence to support the popular impression that red squirrels emasculate their larger relatives.

So-called "mortality before birth," relating to factors that affect the number of offspring, appears to be closely associated with desirable or undesirable food conditions. Following poor mast years, female squirrels may fail to breed during the first and possibly during both breeding periods, or if they do breed may have a reduced number of young. Likewise, the sex ratio may be disturbed because of adverse nutritional conditions. Baumgartner (9) suggests that the number of squirrels per litter in Ohio is greatest near the bottom of a cycle and least at the peak. In southern Michigan Allen (2) reports that the total loss from natural causes is about one-third the fall population.

Losses Due to Hunting. When squirrels are numerous, there are not only more hunters but the average take per hunter also is higher. A 3-year survey on selected hunting areas in Ohio revealed that the average hunter shot eight or nine squirrels (both gray and fox) for the season when the population was high and three or four when squirrels were scarce (6). For Michigan, Allen (2) indicates the normal hunting take is about one-third of the total fall population or the same as the loss due to natural causes. In Ohio crippling losses among fox squirrels average 5 to 11 per cent of the squirrels bagged (4). The 12-gauge shot gun was the favored weapon with more than 60 per cent of the hunters, and approximately 15 per cent each used 20-gauge guns and 22-caliber rifles (4). Between 30 and 45 per cent of the adult females shot were still suckling young from the second litter, indicating that the hunting season (then Sept. 25 to Oct. 10) was opened too early. A later season would avoid this needless sacrifice of young squirrels as yet unable to sustain themselves (8).

Management

Census. No accurate and economical census technique has yet been developed for measuring squirrel populations. Allen (2) and Baumgartner (5) undertook trapping and tagging studies as a means of arriving at the population on a given wood lot. Although such census technique is prob-

ably accurate if pursued long enough, it is both time-consuming and expensive. If the resident population is to be determined by this method, trapping should be delayed until the completion of the fall dispersal. *Track counts* made after a new fall of snow provide a reasonably accurate check on the number of individuals active at that time. The difficulty is that many squirrels remain in their nests during inclement weather and hence are not accounted for. Goodrum (12) lists three other methods that serve at least as fair measures of relative densities on different habitats, but as denominators of absolute populations they are of questionable accuracy. Descriptions of two of the three procedures follow:

The *time-area count* is a method in which the census taker stations himself at an observation post selected at random on the census unit and for 30 minutes counts all the squirrels that come to view. The size of the area under observation is computed by measuring the average "observable distance" and using the figure thus obtained as the radius of a circle. Observations should be undertaken when the squirrels are most active. Otherwise, some of the population are likely to be resting in nests and dens, thus escaping notice. Hicks (13) states that the seasonal peak of activity in Iowa is during the fall months, with the daily peak from 8 to 10 A.M. If the squirrels observed remain on the sample area for the most part and if movement into and out of the sample area occurs only occasionally, the census data can be used to compute the approximate total population, a simple calculation based on comparative areas.

The *census with hunting dog*, or *time-space method with hunting dog* as Goodrum calls it, consists of working through the census unit or a sample of it with a trained squirrel dog, counting the squirrels that take refuge in trees. The reference to "time" with this method apparently alludes to the manner in which Goodrum applied the technique, since he calculated the area covered as being "approximated by comparing the time taken with that required to cover a tract of known area to be in the same [cover] type." If, however, the average size of the area examined is known in advance or determined in some other way, the element of time appears to play no part. This method, like the preceding ones, is useful mainly in estimating relative rather than absolute abundance.

Food and Cover Development. To the author's knowledge no concerted attempts have been made to subject any considerable area of fox squirrel range to intensive management. Until recently, interest in this animal was at best casual. Aside from efforts to control the season of hunting and restrict the legal take, experience in its management has been decidedly limited. Recommended practice, therefore, must in the main be inferred from current knowledge of life history and habits, which as the reader has doubtless concluded leaves much to be desired. Recommendations follow:

1. *Management of forests by the selection principle based on long rotations.*

Only by handling wood lots so that trees are permitted to attain the size and age required to produce large crops of mast and to provide suitable dens can fox squirrels be induced to occupy a given piece of woodland in large numbers and as permanent residents. Younger aged tracts, if suited to tenancy at all, support smaller populations, which often are but temporarily resident. Stands managed on cordwood rotations are classed in this latter category. The management of wood lots within the fox squirrel range by selection-cutting methods is entirely compatible with accepted forest practice.

2. *Control of stand composition to encourage the growth of mast-producing species.* This can be accomplished by weeding operations if necessary and by careful attention to the removal and retention of trees during cutting. The desired degree of control can be effected without addition to the customary treatment that any well-handled woodland should receive. No extra expense is involved therefore. Species to be favored are oaks, hickories, and walnut, as well as beech where this tree species is present and the others are not. From the viewpoint of growing timber, encouragement of oak, hickory, and walnut in preference to other species is usually a sound practice. At least the best species of each genus can be regarded as wholly desirable forest crop trees, and their selection as the dominant element of a stand rarely entails a sacrifice of timber values. This cannot be said of beech, however, since beech is a less valuable commercial timber tree than certain of its common associates, notably sugar maple, basswood, and white ash.

Planting to develop a mast supply is not practicable, in view of the time element involved. Where planting is attempted, it should be restricted to hedges and border plantings of such species as coralberry, wild rose, elderberry, dogwood, bush honeysuckle, mulberry, hackberry, and hazelnut. Even this measure is of questionable merit, considering its cost in relation to the value of food materials produced.

3. *Control of grazing.* Grazing in woodland intended as a habitat for fox squirrels should be strictly limited. Moderate grazing, which leaves the understory relatively intact, is of no serious consequence, but heavy browsing of the type so common in Middle Western wood lots should be avoided. Otherwise, protective ground cover is destroyed, mast fallen to the ground is devoured, and in time the trees become less productive and may even die.

4. *Reservation of certain wolf trees, defective stems, and other inferior individuals when their retention provides needed food materials and dens for resting and breeding.* The reservation of wolf trees is desirable mainly because they produce prolific quantities of mast. In woodland where food supplies are derived in large part from trees of this character, their removal may seriously impair carrying capacity of the fox squirrel range. Decayed trees and dead stubs afford needed nesting facilities, and without reserving

a number of these trees it is doubtful if maximum productivity can be achieved.

5. *Development of cover lanes between wood lots.* Cover lanes connecting neighboring habitats are of prime importance in effecting an equitable distribution of the fox squirrel population. Without them, isolated wood lots well suited to occupancy may be wholly barren. The main function of such cover lanes is to facilitate the fall dispersal of young squirrels. Oaks, if present along roads and between fields, are also excellent sources of squirrel food. These "bridges" between wood lots are best established along fence rows, roadsides, stream banks, gullies, and similar locations where they offer minimum interference to agricultural practice. Hedges also serve the purpose, but this type of cover generally requires planting and care thereafter. Natural lanes of native plants usually spring up quickly if given the opportunity.

6. *Emergency winter feeding.* Resort to artificial feeding may become necessary during years when the mast crop is decidedly subnormal or when the squirrel population is abnormally high. Ear corn is recommended. It may be distributed about the wood lot or made available through the reservation of food plots in adjacent fields. However, efforts to augment an already adequate food supply are not justified, for corn is eaten by squirrels but sparingly while there is yet a store of cached nuts (2). When mast is no longer available, corn is then taken in preference to other native materials.

7. *Establishment of refuges.* Refuges are useful mainly in repopulating depleted range and hence should be carefully chosen with respect to other wood lots and liaison between them. Obviously the lot selected should provide an excellent habitat in itself. Baumgartner (8) recommends a refuge system consisting of four good-sized and otherwise suitable wood lots per township (36 square miles). Hunting and grazing must be excluded; emergency winter feeding should be employed when needed; and native breeding stock, if insufficient to produce the desired population, should be introduced through the release of animals trapped in other localities.

8. *Control of hunting.* Adequate control should include the following provisions. The open season should be delayed until most of the young are no longer dependent on the mother for food and other care. Many juvenile squirrels are left to starve needlessly when the mother is killed before the young are weaned. The length of season and bag limit should be so regulated that the population is not depleted. In southern Michigan it was found that about the same number of squirrels were taken during each of the 3 weeks of the hunting season. Thus, too long a season tends to deplete the breeding stock (2). On the other hand, Allen (2) believes heavy hunting is not detrimental, especially during years when food produc-

tion is low. The length of season and extent of the take are local problems that only careful management and checks on the population level can solve.

9. *Provision for nesting facilities.* The reservation of den trees has already been mentioned. Additional nesting facilities may be provided in the form of excelsior distributed about the woodland in large wads, and den boxes attached to tree trunks. Excelsior supplies building material for external nests, and the boxes take the place of natural tree cavities.

Miscellaneous Management Procedures. *Traps* for catching live squirrels are patterned after the type recommended for the cottontail rabbit, except that they are smaller and permit the entry of light only through the end opposite the entrance, which is blocked off by a double thickness of window glass. The sides, top, bottom, and trap door are built of wood or sheet metal. The former material is probably less durable but cheaper as to initial cost, easier to assemble, and warmer for winter use. Nuts, corn, and apples make attractive bait.

Transfer boxes and handling cages should be about the same size as the trap, with an entrance at one end and a sliding door at the other so arranged that a trapped squirrel can be transferred from the trap to box or cage by placing the two end to end. Any of several materials may be used. Hardware cloth over a metal frame is excellent, being strong enough to resist attempts to escape yet light in weight and airy. A wood frame is likely to be badly chewed and weakened.

If a squirrel must be handled manually for longer than a brief moment, it is advisable to anesthetize it first. Squirrels are vicious, and their bite is painful. A subcutaneous injection of nembutal [1] (a half grain dissolved in 2 to 3 cubic centimeters of distilled water) will inactivate the average squirrel for an hour and cause it no harm (23).

Allen (2) ends his book on Michigan fox squirrel management with the following pertinent remark: "Food and belly fat, shooting and living space, tree dens and protection, healthy squirrels and many litters — that, it seems, is the formula."

EASTERN GRAY SQUIRREL (*Sciurus carolinensis* Gmelin) [2]

Geographical Distribution

The eastern gray squirrel is an arboreal animal found typically in forested regions from the southern parts of New Brunswick, Quebec, and Ontario to Florida, Louisiana, and eastern Texas. Of the five subspecies listed in the footnote only the first two are important, except locally.

[1] Nembutal in tablet form can be purchased from Abbott Laboratories, Chicago, Ill.

[2] Anthony (*13 g.r.*) lists five subspecies: the southern gray squirrel, *S. c. carolinensis* Gmelin, found from southern New York to northern Florida and west to Indiana, Missouri, Oklahoma, and Texas; the northern gray squirrel, *S. c. leucotis* (Gapper), a somewhat larger animal than the preceding one, indigenous to the Northeastern states

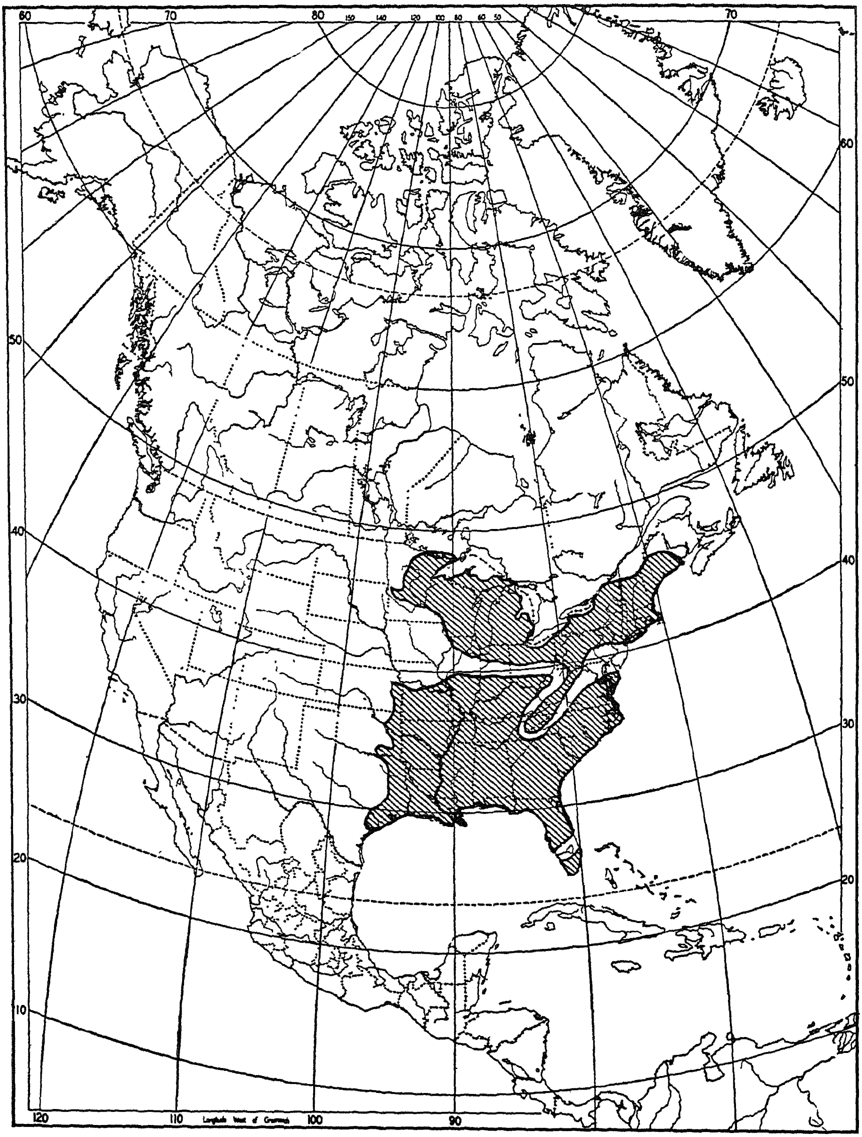

FIG. 6·3. Approximate range of gray squirrels of the Eastern part of the United States. (*From Anthony, 13 g.r. and Hamilton, 52 g.r.*).

and adjacent Canada from New England, Pennsylvania, and Minnesota north (the black phase is common in this subspecies); the everglade gray squirrel, *S. c. extimus* Bangs, occurring in the southern half of Florida; the Louisiana gray squirrel, *S. c. fuliginosus* (Bachman), of the bayou region along the coast of Louisiana; and the Merriam gray squirrel, *S. c. hypophaeus* Merriam, in Minnesota (the limits of its range not known).

Life History and Ecology

Breeding Characteristics. Gray squirrels are promiscuous in their breeding habits (16, *88 g.r.*) and fecund producers of young. Breeding may take place at any time of year but appears to be most prevalent in early winter and again in early summer. Mating is generally prefaced by a pronounced "chase" in which the female is hotly pursued by one or more males, the number being sometimes as many as 25 (16). During courtship males fight among themselves, often viciously. Chapman believes that most females raise but one litter a year, but Anthony (*13 g.r.*) states that they may bear two, and both Goodrum (20) and Hibbard (22) report two well-marked periods of birth in Texas and Kentucky: one in late winter or early spring, the other in late summer.

Like the fox squirrel, the gray squirrel nests in tree cavities or masses of interlaced leaves and twigs, which it builds in tree crotches and forked limbs. In Ohio about 90 per cent of the young are born in dens, some of which the mothers may later transfer to external nests (16). The number of young at birth appears to vary from one to six, the average from two to four (16, 20, 22). Gestation lasts 44 days (*88 g.r.*). At birth the young squirrels are hairless, blind, and very small. Maternal care covers a period of about 6 weeks, after which the young squirrels are able to go their own way unaided. Goodrum (20), however, reports that some semblance of a family relationship is maintained for about 4½ months.

Data concerning sex ratio are few and inconclusive. For each of 3 years the ratio of males to females among 288 squirrels reported by Chapman (16) was as follows: 49:51; 60:40; 39:61, the 3-year average favoring the females slightly.

Movements. The daily movements of the gray squirrel are not extensive but vary with the time of year and the availability of food. Mostly the extent of travel is short, being about 200 yards on the average (20) and seldom more than a mile. They rarely venture beyond wooded cover and except around cities and towns keep to more heavily forested localities. In and about centers of human population they lose much of their natural timidity and roam at will in parks, in arboretums, among shade trees in yards, and along streets. Treated kindly, certain of the less fearful will eat from the hand. In their natural surroundings, however, these animals are extremely wary and wily.

Gray squirrels, unlike the fox squirrel, are migratory in habit. This characteristic appears to be partly inherent and also may be induced by the necessity of seeking new sources of food. Such movements may be more properly referred to as emigration, since gray squirrels rarely return to the original site. Gray squirrel emigrations may indicate uncanny intelligence among these creatures, which move en masse to other localities when food

materials become exhausted in districts where the squirrel population is high. Anthony (*13 g.r.*) comments that in former times "these migrations took on vast proportions as unbelievable numbers of gray squirrels hurried across the country, swimming rivers and lakes and devastating any farm that lay in the path." Seton (*88 g.r.*) quotes Kennicot as stating that "immense numbers congregate in autumn and move off together, continuing their progress in the same general direction (mostly east in that case) . . . ." Emigration on a grand scale occurs apparently only during years of marked squirrel abundance, since no such movement is evident during periods of scarcity. Since the days when squirrels were truly abundant, emigrations have been less frequent and on a relatively minor scale. In most cases present-day seasonal movements may be said to resemble more closely the autumn dispersal habit of the fox squirrel. Fall is the usual season of squirrel emigration, but it also has been observed in the spring (16). How far the emigrants travel is not known, but certainly many miles in some instances. Many aspects of squirrel emigration are not yet clearly understood.

Cover Requirements. The gray squirrel is fundamentally an inhabitant of hardwood forests in large relatively unbroken tracts. With respect to composition and age, gray squirrel habitats strongly resemble those of the fox squirrel. Preferred cover consists of old trees and mast-producing species such as the oaks, hickories, beech, walnut, and butternut, interspersed with other hardwoods like the maples, elms, ashes, gums, basswood, tulip poplar, and magnolia (southward). But with respect to the extent and continuity of their respective habitats, similarity ceases. Fox squirrels are found most commonly in the wood lots and other small and detached patches of woodland characteristic of natural prairie or in agricultural regions. Gray squirrels, on the other hand, occur characteristically in heavily forested territory, where their activities are limited to large blocks of essentially continuous woodland. The tendency to confine their tenancy to wooded cover of extensive area is less pronounced eastward. There, gray squirrels have adapted their mode of living to a densely settled region and often thrive in large numbers where forests in the generally accepted sense are nonexistent. This seeming paradox may be explained perhaps by the fact that in this territory squirrels are not hunted as commonly as farther west and not at all in some states. Then, too, most of the intervening land between communities is forested. In regions where both fox and gray squirrels are indigenous, each tends to occupy a separate environmental type, one in wood lots, the other in forest; intermingling between the two is not common.

Mixed stands containing oaks, hickories, and a large number of other associated species, many not mast-producing, are said by Chapman (16) to be more productive year in and year out than pure oak or mixed oak and

hickory. Chapman concludes that a mixed forest provides a greater variety and more stable supply of food materials and offers superior facilities in the matter of dens, upon which effective breeding appears so dependent. Fox squirrels, it will be recalled, are more numerous in cover running strongly to oak and hickory.

Large trees form an essential element of the habitat. Without them few suitable breeding places are present and food materials are less abundant. Timber stands below 50 years of age are rarely productive sites unless interspersed with wolf trees left from previous cutting operations. Stands nearer 100 years old are much preferred by gray squirrels. Forests must be managed on long rotations to produce either fox or gray squirrels.

Food. Since fox and gray squirrels inhabit wooded lands similar in composition, it is not surprising that their food habits are quite similar. Both prefer acorns, hickory nuts, and other mast to any other food and subsist on little else when these materials are abundant. Of the two species, the gray squirrel seems to be more omnivorous in its feeding habits, consuming in addition to mast a variety of other items, both vegetable and animal, including seeds, fleshy fruits, leaves, shoots, buds, bark, roots, tubers, fungi, insect larvae and pupae, and eggs of birds. Domestic grains, especially corn if available, are eaten during periods of mast shortage, but characteristic habitats are but sparingly supplied with such supplementary sources. Feeding upon corn is far more common among fox squirrels than the gray.

The principal late autumn and winter foods are mast and seeds, augmented in an emergency by buds, pupae of insects found under bark, and roots and tubers where frost conditions permit digging. In spring the main items are cached nuts, buds (especially maple and elm), leaves, fungi, larvae, and insect pupae.

Summer and early autumn foods consist of buds and mast, although in smaller quantities than at other seasons, and fleshy fruits such as grape, mulberry, dogwood, shadbush, hackberry, raspberry, blueberry, and huckleberry. Mast laid by for future consumption is stored in the ground or in crevices and hollow places in trees. During years when acorns and hickory nuts are plentiful, these are the only kinds of mast cached in quantity, but in periods of scarcity other materials are customarily substituted. A common substitute for acorns and hickory nuts in Ohio according to Chapman (16) is seed of tulip poplar. Pine seed or cones are also stored in this manner. Of the two staple forms of mast, hickory nuts are preferred apparently, but acorns are more numerous except locally. Between them they probably comprise 50 to 75 per cent of all food consumed. Stomachs examined by Goodrum (20) in Texas contained 59 per cent acorns. Hickory nuts were present, but trees of this genus were not common in the region studied. He also reports that 3.5 per cent of the diet consists of insects.

Baker (15) includes the seeds of blue beech, ironwood, and black gum as food of squirrels in eastern Texas.

The potential carrying capacity of a particular range with respect to food supply depends largely upon three factors: the total amount of food produced, its seasonal availability, and the amount consumed. Work by Chapman (16) and Hawkins (21) sheds light on the first and third of these three factors. Chapman estimated that the weights of food produced in areas studied in Ohio were 325, 415, and 730 pounds per acre for each of three consecutive years. About 90 per cent was contributed by mast from chestnut oak, pignut hickory, and tulip poplar. The remainder was derived from 16 other plants. Hawkins (21) found the average weekly ration to be 2 pounds per squirrel, or approximately 100 pounds per year.

Concerning *water and mineral requirements*, the gray squirrel appears to differ little from the fox squirrel. Like the latter, the gray squirrel drinks when open water is available but can subsist without it. It consumes particles of gravel and gnaws bones and deer antlers to secure calcium and perhaps other minerals. Chapman (16) found that it consistently ate bits of charcoal, and he concluded that this material was perhaps essential to its well-being.

Population Density. The population level among gray squirrels is decidedly inconstant, fluctuating with the food supply and in accordance with a natural cycle like that affecting the fox squirrel. In years of gray squirrel abundance, an average population of one squirrel per acre of habitable woodland is probably attained in some localities. Densities somewhat exceeding this figure have been tallied in Texas by Goodrum (20), and in excellent cover the number reached two squirrels per acre. In study areas in Ohio, however, Chapman (16) reported between two and ten per 100 acres over a 3-year period, a sparseness of population that would seem hardly typical of the Northeast as a whole. No data are available to prove the latter contention, however. Apparently present populations bear little resemblance to those in times past. Seton (*88 g.r.*) states that early Ohio hunters shot as many as 160 squirrels per day in a state where the average daily take is now about one.

Mortality

Losses Due to the Elements and Predation. When the food supply is plentiful and an ample store of mast has been set aside for winter consumption, losses during cold weather are probably not severe. How great a mortality occurs when mast is scarce or weather more inclement than usual is not known. Possibly at times it may become considerable, but in general gray squirrels seem better prepared to cope with winter's vicissitudes than many other game animals. The principal predatory enemies are hawks, foxes, bobcats, feral cats, and snakes (the last mostly southward). Among

the hawks Cooper's, sharp-shinned, red-shouldered, and marsh hawks are said to be destructive. Evidence against predators is mainly circumstantial or based on casual observation. Few data are available, and the true extent and nature of predation are not known.

Loss Due to Hunting. Hunting has always exerted a strong influence upon the number of gray squirrels since settlement first began, and the present low level measured in terms of former abundance is due in no small degree to the prevalence of uncontrolled hunting in times past and the destruction of mature forests. Data concerning current hunting take and its effect upon productive capacity are meager. Most of these records, like

TABLE 31. HUNTING TAKE OF GRAY SQUIRRELS ON REGULATED HUNTING AREAS IN OHIO DURING THE PERIOD 1935–1940 (18)

Year	No. of areas	No. of hunters	Squirrels seen	Squirrels killed	Take per hunter per day	No. of acres	Take per 1,000 acres
1935	3	2,714	4,500	2,391	0.8	52,000	46.0
1936	3	471	838	284	0.6	52,000	5.5
1937	2	324	222	99	0.3	48,000	2.1
1938	2	912	4,117	1,249	1.3	54,000	23.1
1939	7	1,854	5,396	2,344	1.3	110,000	21.3
1940	10	2,690	6,272	2,747	1.1	126,000	21.7
Totals and averages	27	8,965	21,345	9,114	1.0	442,000	26.7

TABLE 32. HUNTING TABLE OF GRAY SQUIRRELS AND PERCENTAGE OF POPULATION KILLED ON THREE REGULATED HUNTING AREAS IN OHIO DURING THE PERIOD 1935–1937 (17)

Year	Calculated population	Hunting take	Per cent of population killed
Area One, 41,000 Acres			
1935	4,440	2,025	46
1936	1,022	84	8
1937	1,521	86	6
Area Two, 4,000 Acres			
1936	408	60	15
1937	836	98	12
Area Three, 8,000 Acres			
1935	664	206	31
1936	720	102	14
1937	188	13	7

so much of the information presented in this chapter, come from Ohio and Texas. Three conclusions are indicated: (1) Hunting take is greatest during peak years in the cycle, (2) the percentage of kill at such times may be nearly half the population, and (3) areas protected against hunting are likely to support a larger population (20), though not always (16).

Statistics concerning the hunting take in Ohio are shown in Tables 31 and 32. Peak years in the cycle were 1935 and 1940. The two years following 1935 were seasons of scarcity; 1938 and 1939 populations were again abundant.

Management

Principles of management for the gray squirrel are so similar to the recommendations already prescribed for the fox squirrel that their repetition here is not warranted. Census methods, trapping, and other miscellaneous techniques are identical. Manipulations of habitats to improve cover and food conditions are predicated on the same fundamentals. Recommended procedures fit one squirrel as well as the other, with two minor differences. (1) The development of cover lanes advised for fox squirrels is generally not needed in gray squirrel habitats. Woodland frequented by the latter is sufficiently intact and continuous to permit easy travel in most cases. (2) The control of forest composition should be directed toward a mixed forest having mast-producing species abundantly represented but not exclusively so (16).

Whether or not such mixed stands are superior to woodland composed largely of oaks and hickories is perhaps more of academic than practical significance. The theory is that at times when acorns and nuts are scarce, the mixed forest provides substitute materials in greater quantity than the less diversified mixture of oaks and hickories. This is doubtless true; but if a given unit of forest is considered as a whole, the interspersion of natural cover types is usually such that even though oak and hickory predominate over much of the area, other species are sufficiently numerous locally to supply all necessary accessory and emergency foods. The squirrels need only to find these stands, and the fact that they do is well known. Instead of directing the composition of all stands toward a mixed mesophytic cover, it is far better to grow the kind of forest best suited to local conditions of soil and moisture and to limit the mixed mesophytic types to the richer and better watered sites where they occur naturally. If the drier uplands run heavily to oak and hickory, these are the species adapted to grow there, and efforts to alter matters are likely to prove abortive.

The chief difference in matters relating to the management of fox and gray squirrels lies not in the nature of principles and techniques but in the conditions under which they most often must be applied. Fox squirrel

habitats are in the main small in size and under a single ownership, a farm wood lot usually. Because of these conditions fox squirrel habitats afford a splendid opportunity for intensive management. The farm owner is sole arbiter of how and when he will treat his property. He ordinarily works in his wood lot some part of every year and can contribute his own labor at times when other farm duties no longer require his attention. In short, if he wishes to develop his farm to favor wildlife, there are few obstacles in his path except perhaps a lack of knowledge as to how to proceed.

Gray squirrel habitats, on the other hand, are usually large, often remote, and frequently owned by public agencies without funds or large lumber-producing interests little concerned with the welfare of wildlife. Forestry practice is therefore likely to be extensive rather than intensive; and as a consequence, efforts to improve conditions for wildlife must be inexpensive except perhaps when attempted by public organizations having sufficient financial support. Even in such cases expenditures generally must be devoted to the integrated development of the forest property as a whole rather than any single aspect of it.

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Section II

FOREST WILDLIFE

CHAPTER VII

WILDLIFE MANAGEMENT IN THE FOREST

THE FOREST AS A WILDLIFE HABITAT

Vast numbers of wild animals were found in the virgin forests that covered nearly half of North America when settlement began here more than 300 years ago. These original forests were tremendously productive of animal life, particularly animals that depended on climax forest conditions. Passenger pigeons were observed in flocks so extensive they shut out the light of the sun for hours at a time. Audubon in 1813 observed one flock between Hardensburgh, Ohio, and Louisville, Ky., that he estimated at 1,115,000,000. It was believed this flock alone would consume 8,712,000 bushels of food a day, probably chestnuts and acorns. Similar flocks were reported from various other parts of Eastern North America about that same time, and an almost incredible acreage of oak and chestnut forests were needed to maintain this one species. The wild turkey, also a climax forest bird, was likewise found wherever oaks and chestnuts grew (29).

Bison, deer, elk, moose, beaver, squirrels, and hares were all found in the original forests. Seton (*88 g.r.*) estimated that formerly 5 million bison roamed the forested lands east of the Mississippi River, their range extending as far east as Syracuse, N.Y., and Washington, D.C. Sixty to seventy million more roamed the grasslands farther west. White-tailed deer were found throughout the Eastern part of the United States south of the northern coniferous forests. Seton (*88 g.r.*) estimated there were originally 40 million whitetails on the entire range. Throughout the humid regions beavers were found along all the streams and the banks of ponds and lakes. Practically all the small open meadows now in the eastern forests are the results of the silting of streams back of former beaver dams. Forest trees were used by these animals for food and in building houses and dams. It is estimated that in primitive times 60 beavers to the square mile in the Adirondack region were not uncommon, and the total original numbers may have been 400 millions of these fur bearers (*88 g.r.*).

The period of lowest numbers of forest game, in the eastern part of the

continent at least, occurred between 1800 and 1900. During this time the clearing of forests and drainage of swamp lands reached its peak. In New England white-tailed deer had declined in numbers to their lowest population point but were on the increase even before the turn of the twentieth century. In the Lake states beaver and deer made little recovery until after 1915–1920, when law enforcement became effective. The stage was then set for an increase in numbers of both these species, because of the creation of vast areas of hardwood reproduction that followed logging and extensive forest fires.

As the result of a phenomenal comeback in the past 30 years, present populations of the white-tailed deer and beaver are the highest since man came to America. In New England the four Northern states in the region in 1945 had open deer seasons with a total take of approximately 30,000 per year. Michigan reported a total of 44,809 deer killed in 1938, and Pennsylvania 63,687 in 1939. The U.S. Fish and Wildlife Service estimates the total population of whitetails in the United States in 1943 to be approximately 4,200,000.[1]

Beaver are establishing new colonies in the wooded areas of the Northern and Eastern states, and parts of Illinois and Missouri have been restocked with these animals during the past decade. The last beaver colony in New Hampshire was taken out on the Maine-New Hampshire line in 1858, but by 1938 the beaver in that state, through restocking and protection, had reached the surprising total of 7,200.

The present forests of the United States have a high potential capacity to produce forest animals. There are now an estimated 615,000,000 acres of timberland in the United States excluding Alaska.[2] This area is more than one-fourth of the total land area of the United States and in size is about seventeen times the size of Iowa. Of this area 228,173,676 acres (gross) are within National Forest or purchase-unit boundaries (7), and 17,000,000 acres more are in state, county, and municipal forests.[3] The extent of these lands is increasing as the poorer agricultural soils are abandoned or are taken over for forestry purposes. Thus, the possibilities for management of forested lands involve an important part of the total land area of the United States.

Even with a minimum of management, game has increased on National Forest lands. The increase of big game alone advanced from 693,000 to 1,841,000 individuals during the period 1924–1938 (37). This is an increase of 266 per cent over a period of 14 years. This number is only a por-

[1] *U.S. Fish and Wildlife Leaflet* BS–283, 1946.

[2] Marsh, R. B. 1933. Forest-land the basic resources. *A National Plan for American Forestry.*

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tion of the animal life in the National Forests, there being in addition an estimated 2,340,000 fur bearers with plenty of room for environmental expansion.

THE OBJECTIVES OF MANAGING FOREST LANDS

The concept of multiple use of forest lands has now become strongly entrenched in the minds of the public, at least in relation to federal and state lands. The condition of much of the land that formerly was part of the public domain but has since passed into private ownership may be responsible in part for this changing concept. After passing into private ownership, much of the land that was formerly in public domain was ruthlessly exploited and left exposed to needless forest fires and soil erosion. Together with this waste of basic resources, a timber shortage was predicted early in the twentieth century and helped to bring about a public demand for a system of National Forests. An awakening to the need of better use of all natural resources led to an understanding of the possibilities of using identical forest lands for many purposes, including wood production, watershed protection, recreational uses, and wildlife production. An acceleration of the demand for hunting and fishing opportunities due to a greater amount of leisure and better transportation facilities has reemphasized the need for producing more wildlife.

Forest Values. The axe and the gun were the two most useful implements of the pioneer. Both were equally indispensable to the survival of the early settlers—the axe in building a house and clearing the land, the gun in protecting the home and filling the larder. Gradually as sawmills and transportation facilities developed, and as the rich land of the Ohio and Mississippi river valleys was settled and cities began to grow, the demand for lumber increased. Much of the timberland was public domain and could be cheaply obtained. Thus, for 200 years the process of destructive lumbering moved across the continent. As the forests were felled in the East and Middle West, the large logging operations moved to the South and Far West, where the process of logging in virgin stands is still going on.

As civilization advances, the necessity for many people to live and work in congested areas seems to emphasize the desire that is inherent in most human beings—to get away from the city and into the forest. Daily contact with sweltering pavements and close association with other human beings seem to bring to the minds of "the doctor, lawyer, merchant, and possibly even the thief" the desire for solitude in the green, whispering forest. A recent survey of the visitors to the National Forests records 32 million people visiting these recreational areas in a single year (37).

Only within the past 50 years has the value of soil and water been recognized as a national rather than as an individual asset. It is now realized

that both individual and national well-being depend on the proper conservation and use of all our natural resources, and that not only personal comfort but also national abundance of all organic resources depend on keeping the soil in place and protected from erosion, in addition to maintaining a reserve supply of water in the soil. The United States as a nation has felt the detrimental effects of overgrazing, overdrainage, overcultivation, and destructive logging practices, to the extent that many people now recognize the direct relationship of these practices to higher living costs, higher taxes, wildlife shortages, and all of the other ills of an outraged Mother Nature. Much of the land adversely affected by unwise use is not now and never was suited to cultivation, but it did at least support some form of natural growth and a varied wildlife population. A reversal of the drainage process and protection of denuded lands will help to restore again these millions of acres to their past productiveness.

Production of Wildlife Crops. Of all the game species in the United States, the white-tailed deer ranks first. Among the game birds the most important are the ruffed grouse and the woodcock. No other species of birds either native or exotic compares in popularity with these except the bobwhite quail and the ring-necked pheasant. In the Great Lakes and prairie regions there can be added the sharp-tailed grouse, and farther to the South, the wild turkey. Many waterfowl use forested swamplands and marshes for feeding and resting during the migration period as well as for terminal breeding sites. Many additional owls, hawks, and passerine birds use the forests as feeding or nesting grounds. Among the fur bearers found in forested areas are the beaver, muskrat, otter, mink, marten, fisher, and wolverine. Many smaller mammals are also forest inhabitants.

Fish are among the most important assets of a forested region. The brook trout is the most popular, although the rainbow trout, brown trout, and salmon are also found in various parts of forested North America. As an indication of the importance of fish management in forestry, the U.S. Forest Service of Region 9 reports a total of 120,041,438 fish planted during 1938.

The Value of Forest Animals. The meat and fur values of game in the United States run into colossal figures. The Copeland Report (*8 g.r.*) gives the meat and fur values of wildlife as $190,298,270 a year, while the annual value of inland fisheries is estimated as $14,206,099. To these amounts should be added the sum of $404,502,707 as representing the yearly saving in injurious insects destroyed by forest game.

It has been frequently estimated that more than 1 billion dollars is spent yearly by hunters and fishermen and their families. This amount includes the cost of equipment, clothing, gasoline, and hotel bills. Part of these expenditures are made, however, in pursuit of nonforest wildlife.

Finally, no one can accurately estimate in monetary units the health

values of the woodlands to the people of the United States in terms of mental and spiritual rejuvenation.

Integrating Wildlife Management with Other Forest Values. Crops of wild animals, particularly for fur and meat, have been harvested ever since settlement began along the Eastern seaboard. In fact much of the exploration of America was made in the quest for wealth in the form of pelts bartered from the Indians. This harvesting phase of man's relationships with wildlife was pursued so vigorously that in many places there were no animals left for "seed" when management gained a hearing. Gradually, however, there has been a tendency toward a limited type of wildlife management, particularly on Federal lands, and since about 1900 there has been no killing of wild animals in National Parks. In the National Forests an attempt has been made to bring about a condition of sustained yield, but for the past decade, particularly with some species, there have been fewer numbers harvested each year than are produced. The favorable results obtained, however, have been an incentive to better management of other public as well as of privately owned lands.

Wildlife Management as a Major Objective. Wildlife may well be the primary crop that is desired on an area of land. Many estate owners are more interested in fish and game than in the market value of the timber on their property. Of course, many enjoy the beauty of forest trees as well as the wildlife, and no doubt some owners believe erroneously that more wildlife can be raised where the timber remains uncut than where some form of timber management is practiced (23). In general, however, greater densities of game and fur bearers can be raised on land where forestry in some form is practiced (23). Forests belonging to hunting and fishing clubs such as the Woodmont Club in Maryland and the Turtle Lake Club in Michigan are examples of this condition (*11 Deer*). On such properties the management of the forest should be regulated to give a maximum of game and also to ensure a financial return from the timber. Money returns from the wood crops will help to pay taxes and to maintain the club for wildlife production. Publicly owned land should be classified and managed according to its highest use, regardless of whether the emphasis is on timber, wildlife, or some other use.

Wildlife Management as a Subordinate Objective. The primary objective of a large percentage of both privately and publicly owned forest land in the United States will be wood production, since on the basis of meat value alone it would be difficult to justify the ownership of such lands.

Wildlife returns are of sufficient importance, however, to help carry part of the overhead cost and have the advantage of being an annual return, whereas the return from saw timber may be periodic over a long interval of time. A comparison of timber and wildlife returns on an annual per acre basis is shown in the following hypothetical calculation:

		Value
Timber value—annual per acre white pine (60-year rotation; 15,000 board feet per acre at $8 per thousand board feet stumpage value)		$2.00
Wildlife value—annual per acre deer (one to 40 acres; annual harvest one to 200 acres; value of one deer $25)	$0.12½	
Ruffed grouse (one to 8⅓ acres, annual harvest one to 25 acres; value of one ruffed grouse $1)	0.04	
Rabbits and hares (one to 8 acres; annual harvest one to 16 acres; value of one rabbit or hare $0.40)	0.02½	
Fur values per acre	0.06	
Total annual wildlife value per acre		0.25
Total per acre		$2.25

WILDLIFE MANAGEMENT AS RELATED TO THE PRODUCTION OF TIMBER CROPS

The remaining parts of this chapter are concerned with the relationships that are present in a forest where the growing of combined crops of trees and wildlife is attempted. The general requirements of animals will be summarized, together with the capacity of forest land to produce game. An attempt will be made to show how various forestry practices affect wild animals and how these practices can be modified to favor the production of both wood and wildlife crops. Some of the administrative problems of producing and marketing wildlife crops will be given, and also special considerations for the type of forestry needed for handling wildlife in forests that are managed primarily for watershed protection.

Habitat Requirements of Wildlife. The general needs of all animals are much alike, in that each must have a sufficient quantity and variety of food and protective cover to meet its physiological needs for maintenance, growth, and reproduction throughout its life. Special cover is required for hibernating, escape from enemies, molting, and emergency conditions during unseasonably cold, hot, wet, or dry weather. Likewise, special food and cover are required by both adults and young at different stages of development. It is, of course, apparent that the needs of a composite animal population must be based on the individual requirements of each species. It is also obvious that management cannot do the impossible, such as to create a stream of water where no natural watercourse exists. Given an adequate rainfall, however, it is surprising how many simple ways can be devised to conserve and distribute a commodity like water over a wide area of land. The release of one pair of beavers in a valley stream that would ordinarily dry up during the summertime may change a dry valley (and formerly a firetrap) to a well-watered area. Fish, waterfowl, fur bearers, and many terrestrial animals seem to thrive where water is available during the summer months, other things being equal.

Each animal in the forest has a specific set of requirements. The degree

to which these requirements are met will determine the density of animal populations present. If one visualizes the most limited daily needs of a ruffed grouse as a circle on which there are available a place to feed, a place to hide during the middle of the day, a place to get grit, a place to dust, and a place to sleep, one has a simple idea of the necessary travel pattern of one bird for one day. The locality where each of these needs is met may be a maximum or a minimum distance from the other, thus expanding or contracting the daily travel of the bird. Individual animals follow this pattern in search of their daily needs day after day, with some variations of course due to disturbances by predators, man, or other animals that accidentally cross their paths. As the season advances and weather conditions change, the food requirements of each animal change, as does the location of the food. The movements of an animal expand or contract or possibly change to a new location. Thus, over the period of a year we have a daily and a seasonal cycle that tend to follow the same general pattern for any given season.

The daily cruising radius of different animals varies with the size of the animal and other inherent characteristics, not all of which are understood. In general, however, the larger the bird or mammal the longer is likely to be its cruising distance. The mouse, for example, uses less territory than the varying hare. The hare and ruffed grouse have approximately the same cruising radius, but both use less territory than the deer. Exceptions are, of course, numerous, as with waterfowl and some of the fur bearers. The mallard duck may travel 50 to 100 miles a day, whereas the otter covers only 15 to 30 miles daily.

The winter period is the time of the year when both cover and food may be both scarce and of poor quality. This implies longer travel distances for animals in order to get enough to eat and to escape from enemies and exposure. The danger may be multiplied by the presence of snow, which makes it more difficult for some animals to obtain food and sharpens the appetites of carnivores. On the other hand, snow also gives protection to mice, which are the staple source of food for many carnivores.

The objectives of the forest manager in relation to game are twofold: (1) He strives to meet the multiple needs of the species under management as nearly as he can and in as small a space as possible. (2) He also attempts to convert nonproducing, or blank, areas into producing areas. This seems to be a difficult task because of the varying needs of different animals. In practice the needs of the several species may be supplied by including the aggregate needs of all of the species under management within a unit that fits the needs of the species with the lowest cruising radius. Thus if 64 complete units of 10 acres for ruffed grouse are provided within a square mile, the food and cover in these units will probably meet the requirement for deer (6, 12).

Because the production of wildlife is ordinarily a secondary consideration in the forest, the task of meeting the needs of wildlife must be met while the forester is growing a crop of wood. One of the basic concepts of forestry is that of keeping the lands occupied with the growing stock so arranged that a proportion of the forest is of sufficient age and size to be ready to harvest each year. When this is accomplished, a condition of sustained yield is possible. During the process of arriving at this point, the forest must often go through a change from open land to mature trees; and even after a sustained-yield status is reached, each part of the land during the silvicultural cycle goes through all the stages from open or partially open land to conditions as found under mature trees. These changing conditions affect all the plants and animals in the forest, both as to the variety and density of game species and as to the use they make of the forest cover. Thus, a grouse may roost in the stand of 15-year-old red pine in the winter and on the ground under a stand of open 40-year-old hardwoods during the summer. Likewise, deer may bed down in an open stand of 40- to 60-year-old pine during the winter and feed in a stand of 5- to 10-year-old hardwood reproduction in the spring.

The age of trees has a decided effect on the use that wildlife makes of them. Leopold (31) reports a condition in Germany where a gradual birdless condition both as to richness of species and number of individuals was apparent in nearly pure stands of pine and spruce during their younger stages; but as these stands grew older, the number of species increased. The progress of this change was reported as follows:

Age of stand, years	No. of species	Pairs per acre
After 5	5	0.4
After 15	10	0.7
After 40	Hole breeders came in	No density given
After 100	Normal ratio of all birds	No density given

A similar picture of the change in the kind of animals associated with changes in the forest cover is given by Fisher (11) in describing the conversions in the forests of New England. He says:

Neither of these species [ruffed grouse and woodcock] was naturally abundant in the heavy forests of early New England, but from 1870 to 1900, during the period of most rapid reversion of old fields to forest, both species reached the greatest abundance recorded by sportsmen. . . . The process of change from shrubby field to forest was gradual, and during the first 20 to 30 years the combination of vegetation was ideal for the partridge. . . . In the sod under a pine wood there were no earthworms. With the change to certain species of hardwoods, if the situation is not too wet or too dry, the original bed of leaf litter disappears in 15 to 20 years, the current fall of hardwood leaves decay almost annually, and the resulting fine humus merges with the mineral soil, sometimes to a depth of ten inches

or more. . . . On many such areas, once the new forest begins to close up, breeding woodcock have appeared in numbers.

The relation of wild animals to forests of different types is shown by a study of naturally reproduced areas and stands of conifer plantations studied by Edminster (10) in New York state. The artificially planted area consisted of a mixture of various kinds of pines 13 to 20 years old, and the natural forest growth was a mixture of hardwoods and pines. During the winters he found no grouse signs at all farther than 300 feet within the conifers and only 3 per cent of the rabbit signs farther than 300 feet from the edge of the type.

Graham (14) has summarized the relationship of some of the forest types found in the Lake states to fur bearers of various kinds. Table 33 gives this summary.

Table 33. Potential Values to Certain Fur Bearers of a Few Sample Forest Types in the Great Lakes Region (14)

Highly attractive. . . . . 3 Used incidentally 1
Much used. . . . . 2 Practically absent. 0

Type	Condition	Bear	Skunk	Mink	Marten	Otter	Coyote	Beaver	Muskrat	Bobcat
Hemlock-hardwood. .	Virgin with white pine	1	1	0	3	0	1	0		1
	Same without white pine	1	1	0	2	0	1	0		1
	Same near water	1	1	2	2	2	1	0		1
	Same near swamp	2	1	1	2	1	2	0		2
	Cutting in berry brush stage	3	3	0	0	0	3	0	0	2
	Same near water	3	3	3	0	0	3	0	0	2
	Same near swamp	3	3	3	0	0	3	0	0	3
	Closed young forest	1	1	0	0	0	1	0	0	1
	Mature forest	1	1		2		1	0	0	1
Aspen.	3 in. d.b.h. or over	2	2	0	0	0	1	0	0	1
	Same near water	3	2	2	0	2	2	3	0	2
	Same near floodable swamp	3	2	3	0	3	2	3	0	3
Tamarack-cedar.	Mature	1	0	1	0	1	1	0	0	2
	Young dense thickets	2	0	2	0	0	1	0	0	2
Aspen-pine . .	Pine not dominant	2	2	0	0	2	1	0	0	1
	Near water or swamp	3	2	2	0	0	2	3	0	2
Marshland. . .	Cattail, sedge, sphagnum	1	0	3	0	2	0	2	3	2
Jack pine. . . .	Pure pole stand	1	1	0	?	2	1	0	0	1
	Open orchard type	2	2	0	?	0	2	0	0	0
Red-white pine.	Mature	2	1	0	3	0	1	0	0	1
	Mixed with aspen and birch	2	1	0	3	0	1	0	0	0
	Same near water	2	1	2	3	2	2	2	0	2
Open	Burned blueberry lands	3	3	0	0	0	2	0	0	1

Capacity of the Forest to Produce Wildlife. Stand and yield tables of the various species of game in forests of known type and composition are still not a part of standard wildlife or forestry literature of the United States. Some work has been done, however, on measuring both the animal populations and composition of the environment, thus giving us at least a beginning in the process of estimating game crops under known conditions. Moore (33) describes the forest cover of 3,500 acres of forest land in the pine barren lands of New Jersey. In this particular area the forest is of low-grade pine and oak and the demand for wildlife is high. The densities of game animals as indicated by a census are given below:

Species	Acres per Animal
Deer	17
Quail	60 (total range)
Ruffed grouse	360

Conditions of cover and densities of wild animals have been studied in the Huron National Forest in the Lower Peninsula of Michigan since 1935 by the U.S. Forest Service [1] and cooperating agencies.[2] Some excellent data on the relation of forest land of known composition to production of game are thus available. The Huron National Forest has a gross area of 553,845 acres (3) and has been under management since 1909.

Soil and cover of the Huron National Forest are typical of the sandy submarginal lands of central Michigan. It originally supported mixed stands of Norway pine and hardwoods. Practically all merchantable timber was logged off during the late 1800's, and part of the cutover land was then cleared for agriculture. Almost the entire country has been burned and reburned following logging (39) and has since grown up to oak and jack pine or has been planted to various species of pine. Numerous fire lanes and logging roads have been cleared and maintained during the time the forest has been administered by the U.S. Forest Service.

Census and calculated estimates by the U.S. Forest Service over a period of years from 1934 to 1938 show the following densities of deer and ruffed grouse:

[1] Censuses of deer were taken by the method of driving one to several sample sections (640 acres) with the aid of Civilian Conservation Corps under the supervision of the U.S. Forest Service personnel. Censuses of grouse were taken using the King grid method on selected samples. The average of several samples is given in the annual report from which these data are taken. The figures are given as estimates rather than actual census figures but are considered to be exceptionally accurate evaluations. Gray and Hermel (15) of the U.S. Forest Service also reported on a study of the relation of game and cover in planted and unplanted areas in the Huron National Forest.

[2] Professor H. M. Wight (39) of the School of Forestry, University of Michigan, made a study of food, cover, and related environmental phenomena during the summer of 1935.

Species	1934	1935	1936	1937	1938
White-tailed deer:					
Fall census per 640 acres. .		28	40	22	31
Total legal kill . . .	1,955	1,606	2,280	3,029	2,092
Ruffed grouse:					
Fall census per 640 acres. .	.....	61	45	46	40
Kill per 640 acres..........	....	14	7	....	12
Acres per animal:					
White-tailed deer	...	22	15	28	20
Ruffed grouse....	....	10	14	13	16

A number of problems have arisen beginning with the period 1933 when Civilian Conservation Corps labor became available in state and National Forests. These problems center chiefly around such questions as how much open space should be left during planting operations and also how naturally produced areas compare with planted areas in the production of food and cover and their use by wildlife. Gray and Hermel (15) studied 1,632 acres of forest land in the Huron National Forest during 1937–1938 in an attempt to solve this problem (25). Of this total, 359 acres were naturally stocked, 215 acres of the latter were well stocked and 144 acres poorly stocked, 71 per cent of the latter being open.

The following comparison is given:

	Plantations	Well-stocked natural areas
Trees, no. per acre (av.)...	754	689
Red pine, per cent......	73	33.0
Jack pine, per cent.	11	62.0
Oak, per cent....	15	4.8
Miscellaneous species, per cent.................	1	0.2
Shrubs, no. per acre (av.).....	18	8.0
No. of openings per 100 acres	60	33
Average size of openings less than ½ acre in size, acres. .	0.07	0.14
Average size of openings more than ½ acre in size, acres.	1.87	1.24
Total of area in openings, per cent.	13.8	14.8

Census on Aug. 11, 1938, of one section each (640 acres) of planted and unplanted areas gave the following results in terms of the number of birds and mammals present [1]:

[1] The census for the unplanted area was made on Section 33, which was 71 per cent open. The data given on page 152, therefore, are not representative of a census of the game as found on the well-stocked natural areas previously described.

Species	Planted area	Unplanted area (well stocked)
White-tailed deer	16	31
Ruffed grouse	6	8
Squirrel	5	5
Rabbit	3	3
Skunk	1	

In studying the total winter and summer food of 30 treated and untreated forest types in the Huron National Forest, Wight (39) found the following conditions:

Type of land	Pounds per acre	
	Summer foods	Winter foods
Improved:		
Highest:		
Unreleased 13-year-old Norway pine in jack pine-oak type	.....	699.1
13-year-old Norway pine in jack pine-oak type. Jack pine and oak logged off	2,949.9	
Lowest:		
13-year-old Norway pine in jack pine-oak type released by improvement cutting	. .	197.7
Oak-jack pine type, sanitation cutting	626.4	
Unimproved:		
Highest:		
Jack pine-oak type	.. ...	472.9
Brush swamp type	5,267.5	
Lowest:		
Old jack-Norway pine type	186.6	47.2

Based on an extensive study for which only meager data are cited, Wight (39) makes recommendations for the Huron National Forest with relation to planting. These are summarized as follows:

1. Leave an unplanted zone ½ to 1 mile wide along swamps and adjacent to river valleys.

2. Reserve areas in the uplands now stocked with oak, aspen, June berry, etc., and do not plant these to pine.

3. Maintain open areas from 1 to 25 acres in size scattered over the forest.

4. If planting of pine is continued, experiment with tolerant shrubs and trees under the planted pines.

5. Since food plants, when developed for wildlife, may help both to solve the food problem for wildlife and improve the fertility of soil, their growth should therefore be encouraged.

6. Do not replant areas where former plantings have failed.

7. Attempt to develop a normal mixed forest.

8. On state-owned swamps browsed out by wintering deer use deer-license funds to regenerate and establish the maximum quantity of high-quality winter deer food.

The Effects of Wildlife on the Production of Wood Crops. Obviously but a few of the outstanding beneficial and detrimental effects of wild animals on forest stands can be discussed in detail. (1) Not many of these ecological relationships are completely understood. (2) The definition of whether a relationship is good or bad depends on the point of view of the property owner. Furthermore, as Hawley (17) points out, the same animal under differing conditions may be both injurious and beneficial. It naturally follows that the entire relationship of wildlife to the forest must be very complex.

Beneficial Effects. More has been written about the harmful than the beneficial effects of wild animals on forests, because much writing has been done by the forester and little by wildlife managers. Also as a rule damages are less complex and easier to see than are benefits. Frequently the forester has termed *damage* animal activity that is in actuality a benefit to the forest. A typical example is the eating of bark of staghorn sumac or moosewood by rabbits. Neither of these shrubs is considered to be a valuable forest species; therefore any injury to them will reduce competition to valuable forest growth.

Squirrels destroy valuable tree seeds when acorns and nuts are eaten, but they also plant the seed of these species when storing nuts for future use. Hawley (17) states, however, that "the injurious influence of squirrels far outweighs any beneficial effects they may have in aiding reproduction." Birds, in contrast, distribute large quantities of seeds of tree species such as wild cherry, dogwood, and possibly oak.

Sweetman (38) lists 28 groups of birds that are destroyers of insects. Only part of these, however, live in the forests. The woodpeckers are notable destroyers of wood-boring insects, and the flycatchers and warblers are well-known feeders on leaf-dwelling and flying insects. The great horned owl feeds heavily on the varying hare, a species that often does damage to forest plantations (1).

The mammals, particularly the small insect-eating species, are no less important in destroying large quantities of forest insects. Hamilton and Cook (16) studied nine species of insect-eating mammals that inhabit forests and found as high as 257 individuals per acre in a stand of beech and hemlock in New York. These authors estimate that with a population of

100 small forest mammals per acre, 266 pounds of insects would be consumed per year. This is a decided benefit to the forest. Based on sample plot areas, Graham's (13) findings showed that mice destroyed 60 per cent of the cocoons of larch sawflies; he also believes that shrews and mice are among the most important enemies of this injurious insect. Large mammals like the beaver are natural soil and water conservers in the forest, although the benefit of this conservation may be somewhat nullified by the damage they do by flooding and by cutting standing timber.

Detrimental Effects. The detrimental effects of some of the forest animals are well known to the forester. Rabbits, hares, and porcupines often cut terminal shoots and chew the bark from stems that the forester intended for future crop trees. During periods when cyclic mammals like the varying hare reach high-population densities, it is practically useless to try to establish plantations in the Lake states. Direct seeding of oaks and hickories is also impossible when squirrels are numerous. Hawley (17) in his book "Forest Protection" lists deer, beavers, porcupines, rabbits, squirrels, mice and other small rodents, and birds as doing damage to the forest.

All of the animals listed may do serious injury to the forest, particularly when they develop high population densities, as is often the case with porcupines, deer, and varying hares. Deer frequently develop such concentrations as to destroy all forest growth except large trees. The forests of Arizona, Wisconsin, Minnesota (*66 g.r.*), Michigan (*11 Deer*), Pennsylvania (*42*, *43 Deer*), and New York (*64 Deer*) have all suffered from overpopulations of deer. Damage by deer is ordinarily done during the winter period in the lowlands, where deer are forced to congregate because of snow or severe winter weather. In the Kaibab National Forest the overpopulation of deer resulted in part at least from the destruction of the mountain lion for the purpose of protecting livestock. Overpopulations of deer can frequently be prevented if the problem is recognized in time to allow a sufficient number of hunters to remove the surplus. Very large refuge areas, open seasons on male deer only, and seasons closed to deer hunting have all contributed to the condition where deer have overcrowded their range and injured both themselves and their forest environment. With a properly educated public and technically minded state and Federal administrators, damage to the forest can be prevented to a large degree by keeping the herd within the carrying capacity of the range.

The forester ordinarily does not have the power to control both the taking of deer and the management of the forest, but he often does have the power to determine the forest-management policies. If he keeps his forest in the best possible condition for game as well as for wood production, he is in a strong position to demand that control of game be such as to fit the game population to the carrying capacity of the range. In addition to

food potentiality, carrying capacity varies with soil and climatic conditions. Hawley (17) believes that one deer to 40 acres is safe. The U.S. Forest Service Region 9 suggests a deer for 66 acres of mixed hardwoods and conifers. Fall census counts in the Lake states show many places where deer are more abundant than is indicated by either of these standards. Based on a total of 216 inventories, the Wisconsin Conservation Department reported an average of 30 deer per section of 640 acres in the wooded area of that state. This amounts to one deer for every 21 acres and is probably more than can be safely carried by most of the northern Wisconsin forests.[1]

Beaver are not difficult to control, but to have beaver in the forest at all some woody growth must be sacrificed. Beaver are beneficial to the forest because they help maintain large bodies of water that can be utilized for fire-control purposes and also raise the level of the ground water.

Porcupines often do considerable damage to both forest reproduction and mature trees by clipping the buds and stems of the former and eating the bark of the latter. These animals can be kept under control by systematic shooting.

The Effects of Forest Practices on the Production of Wildlife.[2] In order to manage the game in a forest, the forester must first determine whether timber or wildlife is his primary crop; next, whether finances for his operations depend on returns from game or timber; and finally, whether the basis for revenue is the meat value, recreational value, or some other fish or game value of each unit of wildlife produced. In general, the silvicultural practices suggested herein are modifications of established forest practices rather than new or untried procedures. An attempt will be made in the following paragraphs to show both the beneficial and harmful effects of these practices in relation to wildlife (30, 35).

Weedings. Weedings or cleanings are the first cuttings made in young stands not past the sapling stage (trees 4 inches or less at breast height) of both even or uneven age, to regulate the mixture to the advantage of the desirable species and to remove trees of poor form where these are overtopping or interfering with the individuals of better quality. Where only one species is present, the weeding is made to remove the trees of poor form rather than those which are being overtopped. In general, this operation is very favorable to wildlife, particularly to the *browsing animals like deer, cottontails, and varying hare*. In order to comprehend the benefits, one must understand something of the relationships of browsing animals to the forest in its various stages of succession. Ordinarily, cutover or burned-

[1] SCOTT, WALTER E. 1938. Wisconsin deer situation, September, 1938. *Wis. Conserv. Bul.* **3**(10):40–46.

[2] All definitions in this section are based on "The Practice of Silviculture," by Ralph C. Hawley, 1937.

over lands in the Eastern United States will develop a heavy growth of hardwood sprouts or reproduction very soon after cutting or burning. This growth is thick and succulent and is low enough to be ideal food for browsing animals. With a seed stock of herbivores present and some good adjacent cover, the animal population increases rapidly for a period of 10 to 20 years unless hunted too severely. By this time food begins to decrease at the same time that deer and rabbits have increased to high population densities. Under these conditions the browsing animals tend to utilize all young and tender growth completely and intensify the conditions of browse shortage. A weeding operation brings some of the trees to the ground and furnishes a temporary food supply from the smaller limbs of the cut saplings. It also encourages sprout growth, which helps to supply food to the browsing animals. A comparison of the bark and twigs used by rabbits and hares on treated and untreated sample areas in a 15-year-old mixed hardwood stand at the Mt. Toby Forest, University of Massachusetts, showed the following results:

	Treated	Untreated
Total number of twigs eaten by rabbits per acre....	43,375	2,250
Square inches of bark used per acre....	2,999	625

There was less damage to the trees remaining in the treated than in the untreated stand, as in the latter many of the desirable stems showed bark damage. Practically all the work by rabbits in the treated stand was done on stems that had been laid prone by the weeding operation (2, 5, 8).

Hawley (17) suggests several methods of eliminating competition in making a cleaning, including lopping off the tops, partial cutting of the stem and bending it over, and the leaving of one sprout where several are present. All these methods have value to wildlife, both in bringing food within the reach of deer and rabbits and in furnishing a high grade of protective cover, particularly for cottontails.

The U.S. Forest Service wildlife handbook of Region 9 (*2 g.r.*) calls attention to the local nature of weed classification and advises the need of periodic evaluation of so-called "weed" species. For example, alder, which is usually considered a weed species, was used for charcoal in the gunpowder industry during the First World War. In a study of the insects of the forest floor, Kulash (27) found that of six different forest types studied in New England the alder bottom type produced the greatest amount of insects and spiders. This insect-producing capacity of the alder type makes it valuable as a game food habitat, although alder will probably still be considered a weed species by the forester.

Sometimes a weeding removes shrubs, vines, and trees that are injuring promising crop trees in a stand. This operation is not ordinarily detri-

mental if it is limited to the trees and shrubs that influence *crop* trees. Promiscuous cutting of vines and shrubs, however, eliminates much wildlife food and should not be practiced where wildlife is desired (4).

Thinnings and Improvement Cuttings. Thinnings are made in immature stands not past the sapling stage in order to increase the growth rate of the crop trees. Improvement cuttings are made in stands that have trees larger in size than in the sapling stage in order to remove undesirable species or to eliminate trees that are overtopping trees of better form or quality. Thinnings are ordinarily made in forests that have had the advantage of former weedings. Improvement cuttings, in contrast, are made in forests that have not had any former treatment. Hawley (17) states that thinnings should be made sufficiently severe to allow for crown and root expansion, yet not to the extent that the stand becomes understocked (9).

Any cutting operation is of greater benefit to wildlife if the freshly cut material is made available during the winter period between November and April. This gives fresh browse material to the herbivorous mammals at a time when their food supply is likely to be limited. Thinnings furnish the greatest amount of food when carried out at short intervals during the rotation so as to supply additional sprout growth in the stand during regular periods of several years. Cook (9) found that a 25 per cent crown thinning in dense second-growth hardwoods 20 to 30 years old at Stephentown, N.Y., produced a thin, delicate growth of sprouts all of which was high in palatability. He believes this type of thinning produced a better sprout and herbaceous growth than a heavier thinning and that most of the stumps from which the trees were cut in 1935 have now died. Thinnings in coniferous stands tend to encourage the development of an understory of hardwoods as well as vines and shrubs, a process beneficial to wildlife in that it enriches the variety of the cover and the number of food-producing plants.

Improvement cutting, in contrast, necessarily removes more wood from the stand and may take out tree species that are particularly desired by wildlife. However, holes thus made in the canopy have the desirable effect of allowing ground cover and herbaceous growth to come in. In general, variations in the density of stands add attractiveness to the environment for wild animals. Improvement cuttings that limit the stand to conifers alone or even to one species are likely to create a less desirable environment than one that has both conifers and hardwoods present.

Sanitation Cuttings. These cuttings, sometimes termed "salvage cuttings," are made to remove trees that have been injured by fire, wind, insects, fungi, ice, or other causes. Hawley (17) states that these "cuttings should not be made unless the material taken out will at least pay the expense of the operation." Frequently such injured trees are the homes of both birds and mammals. Their removal will reduce or eliminate some or

possibly all of the following groups: chickadees, woodpeckers, flickers, wood ducks, mergansers, bufflehead, raccoons, and gray and flying squirrels. Removal of large trees with hollow boles but which are still alive is especially harmful to wildlife. Hollow trees and dead snags should not be removed unless they are known sources of disease infections or insect infestation or constitute a definite forest-fire hazard. No hollow snag should be removed from within 250 feet of a watercourse or swamp, because of its value to tree ducks or raccoons. At least one dead tree should be left on each acre of forest otherwise treated for the removal of dead or dying trees. A special effort should be made to preserve hollow trees that are serving as homes for tree-dwelling wildlife. Sanitation cutting should not be made from Mar. 1 to Aug. 1 or when birds or mammals are bringing off their young (22).

Pruning. Pruning in coniferous plantations should be confined entirely to the crop trees. Such an operation will not ordinarily leave the stand open near the ground except in scattered spots. Pruning in this manner may be somewhat detrimental to wildlife because it leaves an open spot in coniferous stand where wild animals are likely to take refuge from their predaceous neighbors. Pruning of hardwood trees is usually detrimental, because it leaves the stand in an open parklike condition and removes browse that might serve as food for deer, cottontails, and varying hares.

Harvest Cuttings Adapted to Even-aged Stands (23). Three silvicultural cutting systems have been evolved for making harvest cuttings in even-aged stands: the clear-cutting method, the seed-tree method, and the shelterwood method. Mature forests vary in their desirability as wildlife habitats depending on the species present, whether the stand is essentially deciduous, coniferous, or mixed, and the density of the stand. As stated in the introductory remarks in this chapter, hardwood trees of oak, hickory, and walnut are ideal food-producing types for wild turkeys and gray and fox squirrels. A white pine forest 100 to 200 years old is likely to be somewhat open and to have an understory of hardwood trees and fruiting shrubs. Such a forest is capable of supporting a thin stand of deer and ruffed grouse. In contrast, dense stands of jack pine, hemlock, or spruce from 50 to 100 years old are likely to be quite barren of game. Finally, thick stands of pure hardwoods or conifers are also likely to be less desirable for deer, rabbits, and ruffed grouse than mixed stands.

The extent of the cutting operation itself affects wildlife more than actual cutting of some of the standing trees. When lumbering operations cover wide expanses of territory, as is necessary when water transportation or logging railroads are used, the effect on the habitat of wildlife is often undesirable. The use of motorized equipment, including tractors and trucks, has reduced the size of the cutting operation, which in general is an advantage both to forestry and the management of wildlife. Because of

this change, smaller forest units can be given individual treatment (19). Better roads for both logging and fire protection have also made the various parts of forests more accessible and made the use of smaller cutting operations possible. Portable mills which handle small timber lots have also contributed in keeping the size of the operations small and more widely scattered.

Throughout most Eastern forest regions of the United States the use of any of the clear-cutting methods usually tends to change coniferous stands to a mixture of conifers and hardwoods. This is an advantage to game, as the stand usually retains enough conifers to provide good cover and at the same time increases the variety of food available by bringing in hardwoods.

The seed-tree method of cutting is so similar to the clear-cutting method that there is not much difference in the effect on wildlife. The crowns of seed trees are ordinarily so high as to be of little use to game. If, however, several trees are left in a group, small islands of the original cover are retained on the cutover area and a more desirable condition for wildlife is likely to result. The seed-tree method with conifers does have the advantage of ensuring a future growth of evergreen cover around the seed trees in what is likely to be a heavy volunteer growth of hardwoods.

The shelterwood method of cutting, which removes a stand by several partial cuttings, has much in its favor over the clear-cutting or the seed-tree method. It leaves a portion of the stand intact while another part of it is being removed. This provides game food and cover within the stand before the protection of the older portions is entirely removed. Furthermore, as already mentioned, any cutting process that creates a variety of species and age classes is of benefit to wildlife.

The strip and group shelterwood methods are more desirable for wildlife than the uniform shelterwood method because of the variety of the age classes created and the regularity with which cutting operations are spread in point of time through the stand. These two modifications of the shelterwood method give somewhat the same results as the group-selection method as far as wildlife is concerned.

Harvest Cuttings Adapted to Uneven-aged Stands. The selection systems of cutting may include the single-tree selection, the group-selection, and the strip-selection methods. On the basis of producing desirable wildlife conditions, the group-selection method is more productive than the single-tree selection method. If the group-selection method creates openings with a diameter of more than twice the height of the tallest trees and not more than 10 acres in extent, a desirable condition for wildlife will be created (32). When such openings are produced frequently and when the areas of the older age classes are not more than 600 feet across, all of the forest will contribute to the needs of the animals present.

In theory, cutting by the group-selection method would harvest that part of the stand each year which has reached the rotation age. For example, if 100 acres were to be cut on a 100-year rotation, theoretically 1 acre would be cut each year. In practice, however, 10 acres might be cut any time during each 10-year period, and the same results would be obtained, since the accumulated growth of the stand during a 10-year period would be taken out during the cutting operation.

As has been pointed out by Gabrielson (12), the beneficial effects of selection cutting are somewhat nullified as far as wildlife is concerned if the area cut is in large rather than in small units. As an example, he suggests that in a 100,000-acre unit being worked on a sustained-yield basis under a cutting cycle of 80 years, 25 per cent of the total area should be cut every 20 years, and he also contends that the area most recently cut will contain the best food and cover for wildlife, especially the same species. Theoretically, a block of 1,250 acres would be cut each year under this plan. Instead of cutting 1,250 acres in one block, it is more desirable from the wildlife standpoint to cut 25 lots of 50 acres each, distributed over the 25,000 acres. If this process is continued throughout the 80 years, with the 50-acre units evenly distributed over the 100,000 acres, it would result in building a maximum carrying capacity for game.

With the strip-selection method the same desirable results for wildlife can be obtained as with group-selection method, especially if the strips are not too wide. Long, narrow strips in contrast to round or square areas create a maximum of edge. Edge is always a desirable part of the range for game. If the strips are extensive or broad, the area distant from established cover is least likely to be utilized until the new growth is well started.

During any cutting operation careful consideration should be given to the manner in which the operation affects the needs of wild animals. Trees known to be hollow or defective should be left standing, as such timber will seldom be cut at a profit. Destruction of hollow trees will destroy nesting places for both birds and mammals. At least one seed tree of oak, hickory, or other mast-bearing species should be left on each acre logged.

In the Lake states white cedar swamps are handled differently from other timber types, because the demand for cedar may run to small sizes, even down to 4 inches in diameter. Cedar swamps are particularly valuable for deer because of the food value of the leaves and small stems. Dead cedar trees in swamps ought to be cut to make way for a new growth. In this timber type four seed trees should be left on each acre for reseeding purposes (*2 g.r.*). Logging in cedar swamps should be done during February, March, and April, so as to make the slash available for food while the operation is under way.

Establishment of Plantations. Openings in the forests are essential to abundant crops of wildlife; therefore not all natural openings should be

planted in most instances. Such openings are likely to fill in too rapidly anyway without such encouragement. Then, too, openings may not be good planting sites and will result in a loss if planting is attempted. Openings due to failure of individual trees in plantations will be valuable to wildlife if left unplanted. Over the entire forest area a maximum of 10 to 15 per cent should be left uncovered if the production of game is one of the objectives of the forester.

It has been pointed out that excessive plantation losses occur in the Lake states where plantings are made during the peak of a varying hare population cycle (36). Some protection to plantations will be afforded if a strip 50 to 100 feet wide is left unplanted around such plantations, as these hares dislike to cross open areas unprotected by a tree canopy. When such strips are left, they may be considered as part of the 10 to 15 per cent of the open land that has been suggested as being desirable for wildlife production.

Controversy has developed as to the wisdom of planting extensive tracts in the Lake states to pure conifers, particularly to questionable species like jack pine (34, 40). Extensive stands of pure conifers, particularly jack pine, are not expedient for game production. If such stands are broken up into strips or groups not more than 600 feet across, a more desirable interspersion condition is likely to result.

Regeneration of hardwood trees is spontaneous on much of our Central and Eastern forest lands. The hardwoods, particularly the maples, oaks, hickories, walnuts, cherries, and aspen, are among the best food-producing trees for wildlife. Many of these species are used for browse in their early stages of growth, and the oaks, hickories, walnuts, and cherries are mast producers as mature trees. Although in forestry practice great emphasis has been given to the planting of pine on good sites, the hardwoods are probably as valuable or even more valuable than species like jack pine. Likewise, the regeneration of hardwoods is a spontaneous process and will help prevent erosion on the poor sites as well as produce good wildlife food, give variety to game cover, and help to build up the quality of the soil. Aspen comes in naturally after forest fires in the Lake states, and aside from being a good timber tree for special uses it is particularly valuable as browse for deer, moose, grouse, varying hare, and beaver. It is not good economics to plant a tree of questionable value, particularly where it takes a site already occupied by other desirable trees. The development of mixed stands of deciduous and coniferous species has much in its favor as a natural adjunct to combat the menace of fire, insects, and wood-destroying fungi (26).

Slash Disposal. The disposal of slash in relation to its value as cover to wildlife has been much investigated by foresters and wildlife technicians. Loosely piled brush is useful and valuable as cover to both birds and

mammals. Prolonging the life of slash by a special type of piling may indirectly result in greater damage to wild animals than the good it does, because of the length of time such debris remains a fire hazard. Likewise, recommending a brush-disposal system that is costly to operate and of unknown value will hardly be acceptable to either the forestry or the wildlife manager.

The general plan of slash disposal in the U.S. Forest Service is to burn coniferous slash and to scatter hardwood slash thinly so it lies within 18 inches from the ground (*2 g.r.*). Where the fire danger is not great, the life of slash can be prolonged by piling it in upright or tepee fashion with the small branches down. Brush piled over a log leaves an opening under it that can be used by rabbits as escape or resting cover. If slash is burned in piles or windrows, it creates a desirable dusting site for birds for a year or two thereafter. The burned spot may then grow up to blackberry or raspberry canes, which supply both food and cover for game. In general, the sensible procedure appears to be to leave the slash undisturbed if it does not create a fire hazard and to dispose of it partially or completely if it constitutes too great a hazard.

Forest-fire Protection. Fire if not under complete control is detrimental to wildlife. Animals of all kinds are likely to be destroyed in an intense forest fire. Stream cover is destroyed, and leaching of ash into the stream may kill fish. Ground vegetation used for cover and food by wild animals is usually consumed by a hot fire. Fire under control, however, on limited areas may dispose of undesirable ground cover and provide dust baths, additional food, and cover for game (*35 Bobwhite*).

The development of a system of fire control is generally the function of the forester *because the forest is the basic resource.* Ordinarily the return from game is too meager to justify additional or special fire-control devices for game alone. Frequently the result of the activities of wildlife constitutes a valuable natural adjunct to fire suppression, as, for example, the flooding of dry grassy meadows by beavers.

Administrative Problems. There are a few general rules and practices that the forester may find helpful to guide him in managing the forest for the production of crops of both wood and wildlife.

1. Determine whether wood or wildlife is the primary objective of management. Then bend the processes of production to fit the objective.

2. Maximum wildlife production depends on a suitable and readily available supply of food, cover, and breeding conditions within the daily cruising radius for each species.

3. The conditions indicated in the immediately preceding item are most nearly met by having a maximum number of forest types, including open areas, and a diversity of age classes on the smallest unit of land that fits the requirements of management.

4. Extensive operations over a wide area will give greater wildlife returns than intensive operations on a small area.

5. Slight modifications of standard forestry practices are more likely to be carried out successfully than intensive methods planned primarily for wildlife alone.

6. Forestry practices based on other than a knowledge of their relationship to the life requirements of an animal are dangerous and should not be tried.

The use of a *cover map* is a simple and effective way to keep records of forest operations. This map should be accurate and in sufficient detail to show cover types to a minimum of ½ acre, to give the size and density of the principal cover species present, and also to indicate the density of the understory of both woody and herbaceous plants. The location and extent of marshes, swamps, ledges, streams, and ponds should be included.

An *annual census* of the wildlife crop is an important part of the forester's job in managing forest land (21). The forester must know, at least approximately, the number, sexes, and age classes of the game he is managing. The most casual estimates based on field observations are better than no estimates at all. Census methods are given under the section on the management of each species. On all but small forests, the game census will be based on the summation of samples rather than a count of the entire area (20, 24).

Control of hunting, fishing, and trapping is part of the job of producing an annual crop of wild animals. In order to accomplish this a close check should be kept on all hunters, fishermen, and trappers using the forest. Permits should be issued and collected daily to check the success of the hunters, fishermen, and trappers. When the number of animals produced during any given year minus the breeding stock needed to reproduce the next year's crop has been removed, the permits should be discontinued. Allowances should be made for crippling losses and winter killing in reserving the stock for the following breeding season.

Fur and hides of fur bearers can be sold legally in the same way as timber or livestock. The fur bearers of forest lands, therefore, may be treated like any other merchantable forest resource. In this connection it is well to weigh the relative value of different forest resources. Aspen, for instance, is the chief material used as winter food by beavers. A cord of aspen will maintain a beaver for a year. Commercially, aspen is usually worth no more than $2 a cord for wood if it can be sold at all, whereas a beaver skin is worth $10 to $15. It is obviously good management to harvest aspen as beaver skins wherever possible.

Mink, muskrats, otter, and raccoons are also important fur animals that may add to the income from a forest. A good muskrat marsh will return a reasonable annual rate of interest on a valuation of $10 per acre.

This is a better return per acre than can be obtained from such forest land solely on a wood-producing basis.

WILDLIFE MANAGEMENT AS RELATED TO RECREATION

The forest manager must deal with the recreation-seeking public in the administration of a forest whether he wants to or not. Every secondary forest road is an invitation to motorists to drive through the woods. The careless handling of a single cigarette or match may spell the doom of a forestry business as well as destroy the wild animals that live in the forest. Picnic parties and campers will usually stay in prescribed localities if signs are properly placed and if facilities such as water, toilets, etc., are available in the designated locations.

The State Highway Department in Michigan has recognized the value of attractive forests along the roads of the Upper Peninsula of that state and has purchased strips of forest for the pleasure of the motorist. In parts of northern Michigan one can drive for miles on smooth concrete roads through what appears to be primeval wilderness. From the standpoint of the motorist he is traveling through a land of unspoiled forests. Closer examination, however, shows that the unspoiled forests extend only 200 feet on each side of the highway, and beyond that the usual debris of lumbering is present.

The Michigan Highway Department conceived the idea about 1930 of purchasing a strip of land 200 feet on each side of the highway through timbered country of the Upper Peninsula. The land and timber are purchased entirely from state highway funds and include both virgin and second-growth timber. All logging operations along these strips are done on a selective basis and are very carefully supervised by the Highway Department under rigid requirements of slash cleanup and transportation of the logs. Felled timber is sold to lumber companies or private individuals.[1]

The U.S. Forest Service in the Lake states carries on a special type of silviculture along forest roadways and in the vicinity of recreation areas. Roadside strips from 50 to 300 feet in width are maintained in which there is a definite cleanup of dead and down material, snags, and other debris that constitutes a special fire hazard. These roadside strips are kept as natural as possible. Such species as aspen, white birch, plum, cherry, Juneberry, and other flowering shrubs are allowed to remain.

On camp sites, timber-stand improvements and logging operations are limited to the removal of badly diseased or insect-infested trees and the removal of overmature or decadent trees so that a tall permanent thrifty cover will be maintained.

[1] Personal communication from E. C. Eckert, Chief Forester, Michigan State Highway Department, Aug. 23, 1940.

The planting of wild shrubs and trees in recreational areas and for roadside beautification is limited to native species. All barren or unsightly places in recreational areas are planted to a variety of native deciduous or coniferous plants (*2 g.r.*).

An interpretation of the effect on wildlife of the activities listed will be given in the following paragraphs. Of necessity only a few of these activities have been given. Likewise, the normal effects of these activities may change because of catastrophes like the New England hurricane of 1938, which destroyed much of the mature white pine timber in that region (41).

A strip of timber along a highway may be the only cover left after the lumberman gets through. This is on the profit side of the ledger with relation to wildlife except that it may lure game to the vicinity of a highway where a car or a poacher may destroy it. Planting of trees and shrubs as part of a recreation program is also beneficial to wildlife in providing cover as well as fruits, seeds, nuts, and browse for wild animals. Game may suffer during the hunting season, however, because its food is near a road or a camp where a hunter can easily stalk it.

Fifty to one hundred years from now when these roadside strips have developed into mature timber, they will be less attractive for wild animals than when the trees were younger. This strip of mature trees will furnish cover lanes joining one part of the range to another. Perhaps as this stage develops, the usefulness of such stands will reach their highest value. In addition to being valuable for cover these older trees will produce crops of nuts and mast. The trees in the roadside strips and in picnic grounds and camp sites, as they become decadent and develop cavities, will furnish homes for the hole-dwelling birds and mammals.

In the vicinity of roads, snags which are a definite fire hazard should be felled. These dead snags may be the homes of a few raccoons, squirrels, and tree-dwelling birds, but the risk of fire endangers all wildlife.

In general, large groups of people in a forest are a hazard to game. Disturbances of the habitat and the activities of breeding animals may destroy part of the crop and endanger the brood stock. Public education concerning the danger from forest fires and adequate state forest-fire laws may somewhat nullify the harmful effects of pleasure seekers in the forest with regard to fire (18).

WILDLIFE MANAGEMENT IN RELATION TO PROTECTION OF FORESTS

The maintenance of constant supplies of water is important to both plants and animals of the forest. Maximum growth of timber depends on the retention of soil in place, a high water level, and a forest floor with a spongelike water-absorbing capacity. Many forest soils are thin or subject to erosion. A constant forest cover will help to make them more produc-

tive. A damp forest floor and a constant supply of water also contribute to preventing forest fires.

Forests are recognized as being of high value to the public as a protection of headwater streams. In the Eastern part of the United States the public has spent many millions of dollars to purchase forest land for the protection of watersheds.[1] The relation of forests to public welfare is given as the justification for the suggestions that follow for handling streams and lakes on both public and privately owned forest lands.

1. A forest cover should be maintained along the banks of all streams, ponds, and lakes. No more than 25 per cent of the crown cover should be removed at any one time from a 100-foot strip along such stream and lake borders. Vegetation that has little or no timber value, such as willow, alder, etc., should be left for its food-production value, for shading the stream or pond, and for holding the soil in place (28).

2. Aspen and other weed species should not be removed from within 300 feet of streams that may be used for the production of beaver.

3. Brush and timber on islands should not be cut except as indicated in items 1 and 2. After streams have been used for the transportation of pulpwood, sufficient snags and logs should be left in the streams to replace those taken out by the log drive.

4. Banks denuded of vegetation because of log rollways should be treated so as to prevent soil erosion. Suitable vegetation should be replaced in these areas.

5. River banks that are being badly undercut and from which soil is being washed into the stream should be protected by logs and snags so as to break the force of the stream and allow bank vegetation to reestablish itself.

The value of water conservation already stated is largely aside from the value of water in relation to inland fish and fishing. The value of inland fishing alone is a justification for forest management that favors the maintenance of constant stream and lake water levels. In the National Forests alone there are over 70,000 miles of trout streams and an uncounted number of lakes and ponds. Twelve hundred and fourteen miles of streams and 1,085 acres of lakes have been improved, and 298 nursery ponds have been built for fish in the National Forests during the period 1933–1940. A grand total of 180,471,373 fish were distributed to the waters of the National Forests in 1938 (37).

The National Forests contain only a small part of the waters of the nation. The value of inland fish for food alone runs into millions of dollars, while the value of this form of outdoor recreation is even much higher.

[1] The Weeks Law, Mar. 1, 1911, provided for the Federal purchase of forest land as protection of watersheds of navigable streams.

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CHAPTER VIII

BLACK BEAR

Euarctos americanus americanus (Pallas) [1]

GEOGRAPHICAL DISTRIBUTION

Anthony (*13 g.r.*) gives the present distribution of the black bear as "most of wooded North America." In general, this is probably true, with the exceptions of areas that have a high human population and lands formerly used for agriculture and now reverted to forests but where barriers of one kind or another have prevented the bear from coming back. Thus, western Massachusetts and Connecticut have forested cover suitable as bear range but probably have no bear population because the animal was exterminated from that region and has not spread back into it. The wilder areas of the Northeastern United States and Canada; the northern part of the Lake states and western Ontario; the mountainous portions of New York, Pennsylvania, the South Atlantic states; and the wild forested sections of the Gulf states, together with the mountainous regions of Mexico, the Western United States, Canada, and Alaska, constitute the present black bear range in North America.

Originally the black bear could be found throughout the wooded sections of North America. However, the white man has restricted its range to the large forest areas which, due to rough terrain and associated poor soils, have not been subjected to widespread clearing for agriculture. It is not uncommon to find this animal inhabiting former cultivated areas that have been abandoned and have reverted to second-growth timber. Bears are now present in only those states which have sufficiently rough terrain or large wooded areas to allow them to secure a living without unduly interfering with man's economic interests.

LIFE HISTORY AND ECOLOGY

Breeding Characteristics. Bears breed at 3½ years of age, which makes the arrival of the first young at approximately the time when the female is 4 years old (*66 g.r.*). It is probable that the male likewise breeds at this

[1] The black bear group genus *Euarctos* is represented in the eastern part of the United States by the American black bear, *Eu. americanus americanus* (Pallas) and by seven additional species and five subspecies found in other portions of North America (*78 g.r.*).

age but may possibly be capable of breeding a year earlier. Mating takes place during the last week of June or the first week in July, but this varies with the density of population and the particular locality (5, 7). During the mating period several bears, both male and female, congregate in one area. Then two will pair off and mate in seclusion. It is not known if a male will mate with more than one female. Female bears breed only every second year (*88 g.r.*).

The gestation period is from 7 to 7½ months, the young arriving in January when the mother is hibernating in a winter den (6). Bears are very small at birth, weighing less than a pound, so there is little drain on the vitality of the mother during the gestation period (13). It does appear, however, that the female is slightly different in her habits as compared with the male. She goes into hibernation sooner and, no doubt, selects the hibernating den more carefully than the male.

The number of young vary from one to three, and occasionally even four and five may be found in litters of mature females, but the average litter is two (*66 g.r.*, *88 g.r.*, 10). Some individuals of the litters may be lost even before the family comes out of hibernation. Four cubs have been observed following a female, and five have been reported (10), but one or two is more common than three (*66 g.r.*). This gives an average yearly litter of approximately one cub per female per year after the female reaches the age of 4. The extent of the breeding period of black bears is approximately 20 years, one pair in captivity having had 34 cubs in 13 litters (*88 g.r.*). Less than this number of young would probably have resulted, however, if the breeding had been under natural conditions.

After birth the cubs do little else than nurse for a period of 8 weeks. At 2 months of age they weigh approximately 5 pounds (5). It is not known to what extent the mother sleeps or is torpid during the period following parturition or if the young also participate in a hibernating sleep. It is likely that the hibernation of the mother and young, especially during the latter part of the winter, is a series of interrupted sleep periods rather than a hibernation stupor (1, 13, 16). It appears that the mother gives considerable care to the young and that the winter is a period of limited activity rather than extended sleep. The period of maternal care extends through and beyond a year from birth, since the young hibernate with the mother during the second winter and are reported to stay in a close family group until the second summer, when the yearlings separate from the mother as the mating season approaches.

As with all wild creatures, losses are more likely to occur during the period soon after birth and during the early stages of growth than at a later time. Being exposed to severe weather in the den probably kills some cubs during the early period of life. Little evidence is at hand concerning the loss of bear cubs except the pitiable example one sees of cubs

tied to chains or in cages along the highways of states having laws that allow such mishandling of game animals.

At 10 months of age an ordinary bear cub weighs 50 pounds, according to Gerstell (5), and at maturity somewhere between 200 and 300 pounds, occasionally 400 pounds (6).

Little is known about the longevity of the black bear. Seton (*88 g.r.*) refers to two bears in the zoo at Akron, Ohio, that were still alive after 24 years in captivity but had not bred for several seasons. It is probable, however, that the life of the majority of bears in the wild is much shorter than this.

The coat of a bear is one of its most important assets. The fur of bears is glossy and either black or brown in color from late fall to early spring but looks faded and shaggy during the summertime. These animals shed their winter coats during the early summer, and the growth of new hair is not completed until fall.

The home range of a bear is so large that it appears to man as not being a home at all but rather a wide circuit to be visited at such times when food is available and disturbances are at a minimum. The bear needs a wide area to satisfy its desire for seclusion and to meet its need for food. Seton (*88 g.r.*) gives the extent of a bear range as 15 miles. This may be either too high or too low for individual cases, but in all likelihood a bear does not travel this far except under extraordinary conditions. Distribution of food may lure bears to some particular spot, while the breeding season or harassment by dogs or men may cause them to make long treks. Little authentic evidence is available to prove either short or long habitual movements.

Food. Bears must consume enough food during 9 months of the year to enable them to live through the additional 3 months' hibernation period.[1] This mode of living is an advantage in that the storage of food in the form of fat can be accomplished when the supply of food is plentiful during late summer and fall. A bear will eat almost anything a pig will eat, including carrion, flesh, fish, insects, roots, fruits, berries, nuts, and tree seeds. In the spring, insects and roots are a staple diet before fruits and berries are ripe. In Yellowstone National Park, Murie (8) found bears living almost exclusively on crickets and grasshoppers during the late summer. These insects were picked up in the grass and under partly dried buffalo chips. The bark of decayed logs and stumps is freely torn off and stones are overturned in the hunt for insects and crustaceans. Many kinds of roots are also dug up for food. A favorite root in Vermont is that of the Jack-in-the-pulpit or Indian turnip. As the Juneberries, raspberries, and black-

[1] For a new concept of the relation between food and hibernation of the black bear see J. R. Matson's recent article, Notes on dormancy in the black bear. *Jour. Mammal.* **27**(3):203–212, 1946.

berries ripen, the bushes are pulled down and stripped of fruit. In the fall all kinds of nuts and fruits are eaten, as well as fish if they can be caught.

Black bears have been observed killing fawns (9), but the very fact that some of our best deer herds have developed where there is also a high bear population indicates that the bear is not a serious predator of deer. Bruce (3) asserts that the black bear in California is not a menace to either stock or game.

Twenty-five stomachs of black bears were collected in the George Washington National Forest in Virginia and West Virginia between 1935 and 1938 during the fall hunting season (4). These furnished the basis for data of the kind and amount of foods bears consumed for that locality, which were as follows:

Contents of two well-filled stomachs: (1) 544 cubic centimeters or slightly more than 33 cubic inches, (2) 730 cubic centimeters, or slightly less than 45 cubic inches. Converted into units of weight, the materials in these stomachs would weigh on the average a total of 10 pounds.

Of the 10 most important items aggregating more than 95 per cent of the stomach contents, 7, or about 90 per cent, were fruits.

Table 34 is taken from the investigation referred to above (4).

TABLE 34. PRINCIPAL FOOD ITEMS FOUND IN AN EXAMINATION OF THE STOMACH CONTENTS OF 14 BLACK BEARS

Collected in the George Washington National Forest during November-December, 1935–1938 (4)

Food	No. of stomachs	Percentages of total foodstuffs *
Vegetable:		
Oak (*Quercus*, spp. including *Q. ilicifolia*, *Q. rubra*, and *Q. borealis*)	10	51.99
Blueberry (*Vaccinium* spp., chiefly *V. stamineum*)	5	17.44
Tupelo (*Nyssa sylvatica*)	2	6.57
Chokeberry (*Aronia melanocarpa*)	3	5.14
Grape (*Vitis* sp.)	2	4.75
Greenbrier (*Smilax* spp. including *S. glauca*)	2	2.57
Lobelia (*Lobelia* sp.)	1	1.79
Mountain winterberry and holly (*Ilex monticola* and *I. opaca*)	2	1.07
Buttercup (*Ranunculus* spp.)	1	1.07
Animal:		
Cottontail rabbit (*Sylvilagus floridanus*)	2	3.50

* Total percentage does not equal 100. Data given as originally published.

A number of detailed studies of bear foods are available, but the results show the same general feeding habits (see Table 35).

TABLE 35. SUMMARY OF CLASSES OF FOOD OF PENNSYLVANIA BLACK BEARS BY SEASONS FROM ANALYSES OF DROPPINGS *

Class of materials	Percentage of volume		
	Spring (11 droppings)	Summer (44 droppings)	Fall and winter (65 droppings)
Vegetable	61.8	77.2	94.1
Mammal	8.7	5.7	3.7
Insect	2.1	13.0	0.2
Trash	27.4	4.1	2.0

* From Bennett *et al* (2) and rearranged by Stevens (14).

In Pennsylvania wild cherries are the most important summer foods (52.7 per cent by volume), acorns are next in importance (12.6 per cent), bees and wasps are third (11.5 per cent), mammal remains fourth (5.7 per cent), and blackberries fifth (4.6 per cent) (2). Stevens (14), reporting on the food of black bears in New Hampshire, shows the summer food to be largely vegetable materials, with mammal and insect foods being of minor importance. The food of western black bears, at least locally, is materially the same as that eaten by its eastern cousin, the summer food being more than 80 per cent vegetable materials, animal materials about 12 per cent, and the remainder, garbage and insect remains.

To date there has been little discussion in the recent literature concerning the attractiveness to black bears of corn in the "roasting-ear" stage and livestock, especially pigs and lambs. Judged from the records of early settlements in this country, when farms were small openings in vast forested areas and bears had not yet learned to fear the sting of a rifle bullet or the fangs of the dogs, corn both immature and ripe appears to have been a choice morsel of food to black bears. These animals likewise seem to have been inordinately fond of pork and lambs according to old town histories (12). The current claims of residents of Pennsylvania, Wisconsin, and Michigan for damage done by bears indicate that black bears still like corn and possibly livestock.

The hibernation period in relation to food requirements is nature's scheme of "planned economy." Bears go into the winter rest period without food in their stomachs and are not particularly hungry when they first emerge from hibernation (*88 g.r.*). This winter sleep seems to be a case of suspended animation, so the bear does not require much food during this period. A new theory of hibernation as evolved by Grinnell, Dixon, and Linsdale (6) states that the length of the hibernation period is regulated by the abundance or scarcity of food.

The water requirement of bears is probably much like that of the dog except with respect to quantity, which is correspondingly larger due to this

animal's greater body size. Bears like water and consequently do not live far from it. They drink freely and like cool, muddy places in which to wallow in order to escape from insects and to help, perhaps, in the process of removing dead skin and the winter coat of hair. In bear country, one frequently finds places where a bear has reposed against a log in a puddle of water during the heat of the day. Mud baths are often indulged in, and the runways will be found leading from these locations in several directions.

The Bear Habitat. So little material is available in printed form on black bear habitats that only meager conclusions can be drawn as to what constitutes an ideal bear territory. By inference, however, one can summarize some of the most important items that are desirable and contribute needed items to a black bear's mode of living. The quantitative descriptions that follow will be largely conjectures, since practically no data are available on work done on the ecology of the black bear. In summarizing the situation, however, it seems safe to say that the following cover types are needed for an ideal bear habitat:

Forests. Bears and trees are inseparable. Bears climb trees to protect themselves from dogs and by getting under overturned roots and into hollow trees escape inclement weather. Bears find food under the bark of dead trees, logs, and stumps and eat the seeds and fruits that grow on many shrubs and trees. The edges of the forest appear to be the most suitable place to find grass and woody, fruit-bearing shrubs. Wild berry-bearing plants often spring up where trees are cut or where an area in the forest is opened by burning. Dense brushy vegetation creates ideal summer food as well as cover for bears. A mixture of conifers and hardwoods is important, especially after the frost destroys herbaceous ground cover in the fall, as the bear is a timid creature and will not stay in areas where it fails to find good concealment.

The typical bear habitat in the eastern part of the range is a well-watered, forested area having a mixed stand of conifers and hardwoods of various ages and with numerous streams, ponds, and lakes distributed through it. The variety of cover and fruiting species of plants as well as low forms of animal life found along water courses probably help to make such situations good bear-feeding territory.

Rough Topography. Rough terrain is probably not a bear requirement, except that any area which has level fertile land is also likely to be used for agriculture, resulting in an environment most unsuitable for bears. Many features of a rough terrain aid the bear such as furnishing dry, well-drained dens for winter habitats and conditions suitable for escape from its greatest source of annoyance, the dog. Water is also likely to be well distributed in rough country, a condition that may not be present in flat land.

Population Densities. The total population of black bears in the United States in 1943 as given in the big-game census of the U.S. Fish and Wildlife

Service was 151,653. This estimate is of little value from the standpoint of density of population, because the area of the occupied bear range is unknown. Better figures are available in the report of the U.S. Forest Service for the National Forests, where the total population of black bears for 1943 was 65,688. California has the highest black bear population in National Forests, with more than 15,000 bears in 23,824,377 acres (gross), or one black bear for approximately every 1,600 acres. This is a bear to each 3 square miles. Individual National Forests have black bear populations as great as one bear to 1⅓ square miles. Bear population densities for selected National Forests throughout the bear range are given in Table 36.

TABLE 36. AVERAGE AREA PER BLACK BEAR ON BASIS OF BEARS REPORTED ON NATIONAL FORESTS FOR 1940 *

State	National Forest	Acres per bear
California	Shasta	857
California	Stanislaus	946
Washington	Snoqualmie	962
Vermont	Green Mountains	967
Minnesota	Superior	1,914
West Virginia	Monongahela	2,575
Virginia	George Washington	3,155

* Data taken from "National Forest Areas" by Earl H Clapp, June 1940, and the "Estimate of Big Game Animals on National Forests" as of Dec 31, 1940, by the U S Forest Service.

MANAGEMENT

A state that has a population of black bears and a habitat suited to bear production is fortunate indeed. The bear is a favorite animal of the big-game hunter because of its cunning and agility, and a bear population, if handled properly, will bring in a high revenue in terms of money spent for hunting licenses, ammunition, lodgings, equipment, and food. Also, the bear responds well to even slight protection, and may be hunted year after year without depleting the breeding stock. Many states protect the bear as a game animal and as a result have added a valuable animal to their game list. A few states still harvest the bear crop by the doubtful system of bounty collections.

Little is known about the management of the black bear. To date, protection during closed seasons and control of hunting have produced excellent results in the bear ranges of the United States. In the Northern states the open season on black bears should conform to that for white-tailed deer so that both sports can be followed at the same time. Where the deer season does not open until relatively late in the fall, this may eliminate the possibility of bagging a bear, since it may be so late in the year that the bears have already hibernated. A bag limit of one bear per person should be the maximum take. Shooting the young of the current

year [animals weighing less than 50 pounds (5)] should be prohibited. It should also be illegal to possess native live bears out of season or to exhibit them on chains at any time during the year without a license to do so.

Bear Management in National Parks. The handling of bears in the National Parks is a particular bear problem and requires special rules. Victor H. Cahalane, in charge, Section of National Park Wildlife, has described conditions in relation to bears in National Parks together with rules for the management of those animals as follows:

The general policy of bear management in National Parks is the same as that which applies to all other native faunal species: that they be left to carry on their existence unaided unless there is cause to believe that they are threatened with extermination. This is a laissez-faire, or "let-them-alone," policy. However, since existing conditions are such that certain corrective measures are needed, it is *not* a "do-nothing" policy.

Many management problems of bears and other species arise from the joint use of National Parks by wildlife and man. This joint occupation by human and animal populations in parks is prescribed by the laws establishing them. Management of wildlife in a primitive state is inherent in the National Park concept. Thus, the policy regarding bear-human relations states that the presentation of bears to the public should be a wholly natural one and that the animals should not be encouraged to depend on man for support.

At present, black bears inhabit 14 National Parks, and grizzly bears are present in 4 (Yellowstone, Glacier, Grand Teton, and Mount McKinley). Grizzlies have, to date, given very little trouble to humans. A study of bear damage and injury reports in Yellowstone National Park indicates that in nearly all cases black bears are involved. They are more numerous, less shy, and more adaptable than grizzlies. The black bear-visitor "problem" (injuries to visitors and property damage) has been and is of most concern in Yellowstone National Park. In other areas where bears have been troublesome, encouraging progress has been made toward a solution of the problem.

Former practices of bear presentation involved feeding of garbage at areas of human concentration. These "bear shows" not only gave an unnatural presentation, but a heavy concentration of bears eating unnatural food may well have facilitated the spread of diseases and parasites. Availability of unnatural food tended to lower the health of the animals and has resulted in perversion of their natural mode of life. Feeding of bears along roadsides and other places by visitors was encouraged—with trouble as the inevitable result. It has been shown that the bear problem is due, not to the innate ferocity of the bears themselves, but almost entirely to abnormally intimate contacts which humans have sought to establish with bears.

The following management practices are in operation:

1. Existing regulations prohibit the feeding or molesting of bears. Visitors are warned by lecturers and signs not to feed bears and that it is dangerous to approach them closely. Educational campaigns have been effective in many parks in reducing the number of injuries to visitors.

2. Black bear "shows" and feeding grounds have been eliminated with favorable results. The canyon feeding grounds in Yellowstone were abolished during the summer of 1942. This had been operated in the past in order that visitors might see grizzlies, which are generally difficult to observe under natural conditions in the park. It is too early to state what effect this will have on bear-visitor relationships.

3. Bear-proof garbage and food containers are used at camp grounds to reduce their attractiveness to the animals.

4. Electric fences have been used successfully at Mount Rainier and Yosemite National Parks to keep bears away from buildings in which groceries are stored. Electricity also has been used in Yellowstone with some success to protect fish spawn-taking traps.

5. Persistent bear offenders are live-trapped in portable, corrugated iron cage traps and removed to isolated sections of parks. This measure is believed to be about 30 per cent effective in Yellowstone National Park. An unknown percentage of the troublesome bears removed return to the areas in which they are trapped.

The most dangerous bears are eliminated by shooting. It is recognized that killing animals as they become troublesome may keep down the numbers of persons injured and property damaged, but it has no preventive effect. It is not a solution to the problem.

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CHAPTER IX

DEER [1]

White-tailed deer, *Odocoileus virginianus;* mule deer, *O. hemionus;* Columbian black-tailed deer, *O. columbianus*

GEOGRAPHICAL DISTRIBUTION

It is perhaps no exaggeration to say that of all our native mammals none has played so important a role in the history of America as the deer, and today no other is better known or more widely prized as game. Formerly, nearly half of our country was covered with forests, and throughout these wooded regions deer were present. Early settlers along the Atlantic coast and those who pushed westward over the Alleghenies found the eastern whitetail, and beyond the flat prairies in the broken terrain of the plains land, the Rockies, and farther West they encountered the mule deer, a slightly different animal from the eastern deer with a black-tipped tail and peculiar high-bounding gait.

To these early pioneers no other animal was more sought after, none more useful. The flesh was tender and nutritious, and from the skin came sundry articles of clothing—jackets, trousers, leggings, moccasins, mittens, and even caps and underwear. The fat or tallow made excellent candles and waterproofing material for moccasins and wearing apparel. Even the antlers were put to use as knife handles, as racks for clothing and guns, and as gun sights (2).

The present deer population of the United States numbers more than 3½ million. This is a marked reduction from the original population, which Seton (*88 g.r.*) estimated to be 40 million. During the 1800's deer all but disappeared in many localities in the East, but the last 50 years have seen a sharp reversal of this trend in many sections, though by no means everywhere. Moreover, the great increase in abundance continues at the present moment, due in part to effective conservation policies, in part to the ex-

[1] The genus *Odocoileus* (deer) is represented by 31 species and subspecies in North America (*78 g.r.*). The most important groups are the white-tailed deer of the East, *O. virginianus*, and the mule or black-tailed deer of the West, *O. hemionus* and *O. columbianus*. Each has several subspecies, some of which are *O. v. virginianus* (Boddaert), the Virginia deer; *O. v. borealis* (Miller), the northern white-tailed deer; *O. h. hemionus* (Rafinesque), the Rocky Mountain mule deer; *O. h. californicus* (Caton), the California mule deer; and *O. c. columbianus* (Richardson), the Columbian black-tailed deer. The text may refer to several species or subspecies not listed in the title.

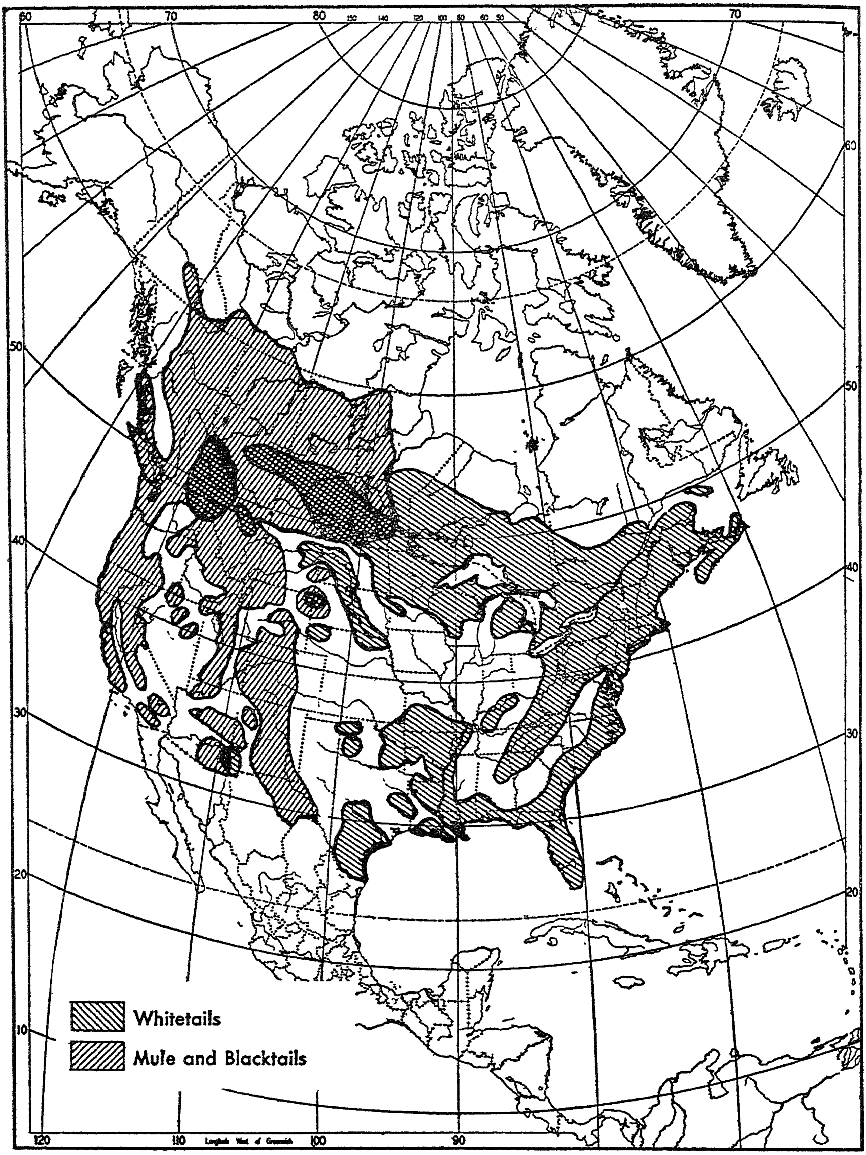

FIG. 9·1. Ranges of white-tailed, mule, and black-tailed deer in the United States and Canada. (*By C. H. D. Clarke, Toronto, Canada,* 1941. *U.S. Fish and Wildlife Service,* 1943.)

tensive area of second-growth hardwoods of various ages, and in part to the abandonment of submarginal farms. So despite a heavy toll taken annually by hunters, the deer is in no danger of extermination.

The range of the white-tailed deer is not known to an exact degree but

extends throughout the forested portions of the Eastern half of the continent from Florida to the southern tip of James Bay and westward in the north to eastern British Columbia, Washington, and Oregon (*13 g.r.*) but is not found in abundance in these western regions.

The black-tailed deer—less at home in heavy forest than the white-tailed—inhabits the plains, foothills, and mountains west of the prairies; it is found southward from central Manitoba, central Alberta, and eastern British Columbia to northern Mexico, while east and west, its range extends from about longitude 95° west to the Pacific coast (*13 g.r.*).

The limits of deer distribution, particularly in the East, have undergone changes since the day of the early pioneer, contracting in regions of extensive agricultural activity, such as the Ohio and Mississippi River valleys, and expanding in regions where the establishment of second-growth hardwoods have followed the cutting of conifers, as in northern New England and southern Canada. Unlike the case of so many other animals formerly found in districts now settled, settlement in itself—unless accompanied by extensive clearing of land—has nowhere caused the deer to retreat to remote and inaccessible regions. In fact, certain densely populated sections now support heavy concentrations of this remarkably adaptable animal. Another factor having a marked influence upon distribution and to an even greater extent upon deer population increases has been the acquisition of large land holdings by individual states and the Federal government. Control of hunting and the enforcement of game laws have also played an important role in increasing deer numbers.

ANATOMY, LIFE HISTORY, AND ECOLOGY

Morphology. The principal distinguishing feature of the eastern white-tailed or Virginia deer is its rather large bushy tail, conspicuously white on the underside. Held erect, this is the familiar "flag" of the whitetail known to everyone who has seen this animal bounding away in sudden flight. Unlike its western relative, its antlers have unbranched tines. The black-tailed deer is distinguished by its smaller tail tipped with black instead of white, its much larger ears, dichotomous antlers, and larger metatarsal musk glands.

Weight. Weight varies with several factors, the most important being sex, age, and locality. The average adult male whitetail weighs between 100 and 200 pounds, but larger specimens of 300 pounds or somewhat more are not uncommon northward, and weights in excess of 400 pounds have been reported (*88 g.r.*). The average weight of 89 bucks shot in Michigan ranged from 147 to 193 pounds. Females are not so large as males, 200 pounds being about the maximum, with the average weight between 100 and 150 pounds. Eight adult does reported by Schoonmaker (71) in New York varied from 130 to 160 pounds and averaged 145.

Older animals, as one might expect, usually attain larger size, and the very heaviest are bucks having 10 or more points. Schoonmaker (71) found that fawns 6 months old weighed about 100 pounds, spike-horn bucks from 125 to 150, and 4- to 8-point bucks between 160 and 200 pounds. Weights of animals having 10 or more points varied considerably, ranging from 200 to nearly 400 pounds, with size and weight having little relationship to the number of points. Apparently, these animals had reached the stage of development beyond which an increase in age had little further effect upon size and weight. Southern deer are smaller on the average and rarely attain 200 pounds (67).

Black-tailed deer are more solidly built than whitetails but are of smaller stature, the average male weighing 150 to 200 pounds and unusually large animals somewhat exceeding 400 pounds (30, 31).

Both whitetails and blacktails display variation in weight according to locality, the whitetails being larger in the North and the blacktails reaching their maximum size in northern California (30, 31).

In comparing the size of deer it is customary to express the comparison either in live weight or in weight after bleeding. Weighing the bled carcass may be accomplished without great difficulty, but rarely is it convenient to determine live weight by direct measurement, and therefore it must be estimated by some other means in most cases. The dressed weight increased by one-quarter approximates the true live weight within reasonable limits of error (*7 g.r.*).[1]

Antlers. Only male deer have antlers. These are shed each winter, usually from late December to March. New antlers appear from 2 to 6 weeks later, attaining their full size by late summer. During their period of growth, the developing antlers are covered with a delicate vascular membrane called "velvet," which eventually separates, once growth has ceased, from the bony structure beneath and gradually wears away or is rubbed off. Shedding of the velvet takes place in the late summer and fall, after which the mature antlers are then no longer sensitive or easily injured. At this time the buck, urged on by the physiological changes due to the approaching breeding season, spends much time rubbing the antlers against limbs and tree trunks until the velvet has disappeared and the tines are polished to sharp points.

The initial set of antlers are small, short, and unbranched, giving rise to the commonly used expression "spike-horn buck." Subsequent sets are stouter, broader, more curved, and ordinarily branched, the degree of branching being roughly indicative of the buck's age, although by no means precisely so. Beyond the fact that large well-developed antlers usually

[1] A more accurate estimate of true live-weight from dressed-weight data can be obtained by using Hornaday's (*7 g.r.*) formula: Live weight $= \dfrac{\text{dressed weight} \times 100{,}000}{78{,}612}$

occur on the older and heavier animals, there is no dependable relationship between age and the number of points, a fact quite contrary to common belief (*7 g.r.*).

On the other hand, age and the thickness of the antlers near their base appear to be closely correlated (16). Thickness is measured as the average diameter of the beam ½ inch above the burr (the beam being the main shaft of each antler and the burr the expanded base of the beam near the point of attachment to the skull). The relationship between age and diameter at this point is shown in Table 37. These data were collected in northern Michigan and if applied outside the northern portion of the whitetail's range are of doubtful reliability.

TABLE 37. THE AGE OF ADULT WHITE-TAILED DEER IN RELATION TO DIAMETER OF ANTLERS

Based on 260 skulls collected in Michigan (16, 17).

Age, Years	Diameter of Antlers, Millimeters *
1½	Below 21
2½	21–27
3½ or 4½	28–35
5½ or more	36 and over

* Measured on beam ½ inch above burr.

Breeding Characteristics. *Mating.* Sexual maturity is attained by both sexes at 1 year of age. There is reason to believe that an occasional early-born doe may be capable of breeding during the mating season the first fall after birth.[1] However, there is no evidence to show that this is true of early-born bucks; it is, in fact, quite probable that even when sexual maturity has been reached for certainty a year later, the younger males are frequently frustrated in their mating attempts by older and stronger competitors. Doubtless this latter condition is less evident when the sex ratio is greatly unbalanced, as it commonly is where does are protected during the hunting season.

Mating or rutting begins in the autumn, usually in October in the North but somewhat earlier southward. The rutting urge develops in the male earlier than in the female and continues for a month or more under ordinary circumstances but longer if there are females as yet not bred.[2] According to Newsom (62) the mating instinct appears to be strongly stimulated by a

[1] This surmise has been substantiated by the findings of E. L. Cheatum and Glen H. Morton; see On the occurrence of pregnancy in white-tailed deer fawns. *Jour. Mammal.* **23**(2):210–211, 1942.

[2] For recent data on this point see the article by E. L. Cheatum and Glen H. Morton, Breeding season of white-tailed deer in New York. *Jour. Wildlife Mangt.* **10**(3):249–263, 1946.

succession of cold frosty nights. A secondary sex character in males is a swelling of the neck, quite noticeable during the active mating period. The first oestrual period in females begins sometime in November, probably lasting several days, and is repeated at intervals until March or possibly April if conception has not taken place. The length of the oestrual period and its frequency of recurrence are not known precisely. That they recur until late in the winter is evidenced by the occasional appearance of unusually late-born fawns (37, 38).

All animals having antlers are said to be polygamous (*66 g.r.*), and this is most certainly the case with deer as we now know them. It is interesting to note, however, that Seton (*88 g.r.*) believes the white-tailed deer tends toward monogamy where the sexes are equally represented, as they probably were in their undisturbed habitat, and in this same connection it is again noteworthy that gamekeepers in European forests regard a 1:1 sex ratio as ideal and tolerate nothing more unbalanced than two does for each buck. Whatever the ideal or the natural relationship, present populations are unquestionably polygamous. In circumstances where the females greatly outnumber the males, it is quite probable that one buck will mate with as many as 10 does and possibly more. Physiologically, there appears to be no reason why a larger number cannot be bred. By actual trial 17 does have been mated successfully to a single male during a breeding season of normal length, with no apparent ill effects upon the male or the size, number, and vigor of offspring (38).

During the rutting period the males move about extensively, considerably in excess of their normal routine at other seasons, seeking receptive females and fighting with other males. Females in heat appear to be sought out and followed mainly by the sense of smell (62).

The polygamous instinct is well established in the mule deer also. It has been stated (30, 31) that in these species the mating process is highly selective, the stronger and more vigorous males being the principal progenitors of the race. In Dixon's opinion 90 per cent of the effective breeding is accomplished by a small number of dominant bucks, which prevent the younger and also the older, less active animals from taking part.

Period of Gestation and Number of Young. The period of gestation for both whitetails and blacktails is approximately 7 months, varying from 205 to 212 days (*88 g.r.*, 30, 31) or possibly somewhat longer (62).

May and June are the usual months of birth, but fawns conceived late in the mating period are born during the summer months and sometimes as late as October (37). Does having young for the first time bear a single fawn. The number thereafter may be one, two, three, or even four but rarely more than two and commonly only one. Data collected in Minnesota suggest that the number of fawns borne by each pregnant female averages about 1.3, with twins occurring once in every four or five births

(4, 48). Not all females are bred, however, and the ratio of fawns to does, both pregnant and barren, is therefore less than 1:1. On the basis of census figures obtained in Michigan over a period of several years, the ratio of fawns to does appears to vary between 1:1.1+ and 1:1.2+ (6).

Rearing of the Young. As the time for fawning approaches, the pregnant female abandons her usual routine and steals away to some well-concealed spot, usually a thicket of shrubs or small trees, and there gives birth to her young. Newly born whitetails weigh from 3¾ to 5 pounds (*88 g.r.*, 3), and blacktails from 5 to 8 pounds (30, 31). The young fawns at first are decidedly weak and helpless; and being unable to move about actively for several days, they remain in hiding beneath clumps of shrubs or other similar cover. During this period the doe often leaves her offspring for several hours at a time to forage in the immediate neighborhood, but at night she remains in almost constant attendance.

Hiding the young during the day and feeding them at night appears to be the typical rearing routine of all deer during this early period of extreme helplessness and dependency of the young. Protection at this critical period is afforded in part by the mother but mainly by the concealing vegetation, the protective coloration of the fawn (the spotted body blending perfectly into the sunlit foliage), and its reported lack of scent (30, 31).

As soon as it is physically feasible, the mother leads her offspring away from the initial place of hiding, and thereafter they forage together, never being long or far separated. During the first month and perhaps longer the hiding-out technique is continued, but with decreasing frequency. Once a fawn has become truly agile and capable of sustained travel, it follows its mother rather closely, particularly until after the period of weaning, which usually begins when the fawn is about 4 months old. This family relationship is maintained until the following spring, except for a brief period during the mating season when the association of mother and young is disrupted temporarily. It is quite probable that the final dissolution of the family tie is brought about by the mother, the offspring being reluctant to assume complete independence through its own initiative.

Sex Ratio. There are two distinct aspects to the matter of sex ratio: the ratio among adult animals and the ratio among fawns at birth. The ratio of adult males to adult females in any one herd is greatly influenced, of course, by the hunting laws then in force. Where hunters may shoot animals of either sex, the ratio is probably reasonably well-balanced, although there is no concrete evidence to support this belief. In states where only bucks may be shot, this practice eventually leads to a highly unbalanced condition in which the females are far more numerous than the males. Trapping records in Michigan suggest that an adult population having four does to each buck is not unusual (58). In heavily hunted sections even wider differences probably exist, particularly during the

interim between the winter hunting season and the appearance of fawns in the spring.

The composition of a typical deer herd under conditions where only bucks are shot is suggested by census data of the summer population in Michigan (6). These data are summarized in Table 38.

TABLE 38. THE DISTRIBUTION OF ADULT MALES, ADULT FEMALES, AND FAWNS IN THE SUMMER DEER POPULATION OF THE UPPER AND LOWER PENINSULAS OF MICHIGAN AS SHOWN BY CENSUS DATA (6)

Year	Upper Peninsula			Lower Peninsula		
	Adult males, per cent	Adult females, per cent	Fawns, per cent	Adult males, per cent	Adult females, per cent	Fawns, per cent
1932	23	42	35	13	43	44
1933	25	40	35	15	48	37
1934	22	47	31	15	49	36
1935	19	43	38	10	47	43
1936	19	46	35	12	46	42
1937	18	44	38	10	53	37
Average	21	44	35	12	48	40

The *sex ratio at birth* seems to be about equally divided between males and females or nearly so under normal circumstances. The trapping studies in Michigan referred to above are a case in point. Among 910 fawns captured in these operations, the two sexes were almost equally represented. Nor is this fact particularly noteworthy, for it is perhaps the relationship one might expect. But there appear to be modifying factors which suggest that the 1:1 ratio is no longer typical when habitat conditions are unfavorable. For example, a tabulation of fawns killed on heavily browsed range in Pennsylvania during the open season of 1935 disclosed the very interesting revelation that the number of females exceeded the males by about two to one (39). The point that deserves particular emphasis here is not, however, the distorted ratio as such but the fact that the degrees of distortion seemed clearly related to the quantity and quality of available browse. In the several counties where food supplies were considered ample, the ratio was 1:1.2 or 1.3, whereas ratios in the four counties most heavily overbrowsed ranged from 1:2.5 to 1:4.0. The fact that more than 11,000 animals were included in the tabulation gives substance to the findings. On the strength of this data the Pennsylvania Game Commission is now engaged in further research on this particular aspect of the deer problem.

Longevity. Physiologically, there is no reason why healthy white-tailed deer may not live to an age of 15 years and perhaps somewhat older, but the longevity of deer in the wild state seldom attains this maximum, since

the pressure of the environment apparently is too great. Where does are protected, they probably live longer than unprotected males, and only the more wily or fortunate individuals of this latter group survive to the period of old age. That older male deer are not common is indicated by data on age distribution in Michigan. Animals 5½ years old and older are estimated to comprise but 8 per cent of the total male population (16).

Movements. The habits of deer with respect to their movements and cruising range have two distinct aspects: (1) the daily routine concerned primarily with the quest for food, water, and suitable resting cover and (2) the seasonal aspects controlled in the main by climate (15).

As one might expect, the daily routine is strongly influenced by the nature of the seasonal habitat. During the months when cold weather and deep snow inhibit free movement, activity is reduced to a minimum. At other seasons, the normal daily circuit from resting cover to feeding and watering grounds and return may range from 2 to 10 miles; in some cases, it may be no more than a few hundred yards. Topography, cover conditions, temperature, and the situation with respect to insects and predators all play a role in determining the day-to-day habits of any individual deer. Feeding and drinking are confined mainly to the early morning hours near dawn and the twilight period of evening. At these times the banks of water courses, the shores of ponds, and the adjacent territory are more commonly frequented than the higher, drier uplands. The hours between feedings are periods of desultory activity during which the deer alternately rest and cruise about, usually on upland terrain and almost always in wooded cover, though sometimes in relatively open cover. Elevated ground exposed to the wind provides a preferred resting site when temperatures are high or insects prove more troublesome than usual.

Adult males are particularly active during the rutting season. At that time their efforts to locate susceptible females often involve travel considerably in excess of that normally indulged in at other seasons. Does tend to move about less freely than the bucks at all seasons, particularly during the spring fawning period when their activity is strongly influenced by the dependent condition of the newborn young.

The seasonal behavior of the whitetail depends largely upon the severity of winter and the depth of snow in particular. During the summer many parts of the range are suitable for occupancy, especially the uplands, but in winter only the more sheltered sites provide the protection required by the overwintering animals (3). At this season, therefore, the population is less widely dispersed and the degree of dispersion is a variable of the weather.

Where winters are customarily mild and snow rarely accumulates in sufficient quantity to impede easy travel, as in the southern portion of the range or during an open season in its northern reaches, the contrast be-

tween winter and summer habits is not marked. The herds tend to congregate in protected valleys away from cold, penetrating winds, avoiding the more exposed uplands for the most part and preferring stands of evergreens to open hardwoods during the periods of colder than average weather. In the main, however, movements are relatively uninhibited, and between cold snaps a considerable portion of the range is habitable. On the other hand, where winters are more severe and the depth of snow greater, the areas of concentration become more rigidly defined and daily movements are greatly hampered. Such conditions engender what are commonly called "yards"; and when weather conditions are particularly inclement and uncongenial, activity is confined almost wholly within their limits; passage from one yard to another being both uncommon and difficult. This is the typical winter condition found in northern New England, New York, Michigan, Minnesota, and southern Canada. Cedar swamps are favorite yarding sites in these regions.

The extent of seasonal movement from winter to summer range presumably varies from region to region and among localities within a region, depending upon conditions of cover and the density of population. It seems evident, however, that the whitetail possesses a definite "homing" instinct and is commonly to be found in the same winter and summer habitats year after year. Trapping records in Michigan suggest that in about 80 per cent of the cases the summer cruising radius is no more than 16 miles, this appearing to be about the extent of movement on the summer range (58).

In regions where oak is an important component of the forest, there is even a more marked movement of deer populations during the fall to stands where this variety of tree is especially abundant, since the mast produced by oak trees is a most nutritious and palatable food at this season.

The seasonal behavior of the black-tailed deer differs from that of its eastern relative. Unlike the whitetail, this deer migrates with the seasons; in winter it inhabits the rolling foothills and lower mountain slopes, mostly below elevations of 3,500 feet, and in summer it occupies the mountain meadows and forests along the higher slopes near timber line at altitudes between 4,000 and 12,000 feet (30, 31). Dixon gives the following record as an estimate of the average dates of arrival of blacktails at different elevations during the spring migration on the western slopes of the central Sierra Nevada Mountains in California:

Elevation, Ft.	Date of Arrival
4,000	Mar. 10
5,000	Apr. 10
6,000	May 5
7,500	June 5
9,000	July 5
10,000	Aug. 5

The upward trek in the spring appears to follow closely the development of new plant growth and therefore varies as to time of occurrence from season to season. The summer range is reached ordinarily before the fawning season begins but generally proceeds at a leisurely pace. By contrast, the fall migration to the foothills below is sometimes precipitate, especially when fall snows come early and without warning. The downward journey is completed well in advance of the rutting season.

During this seasonal migration, the distances traversed are surprisingly large, varying on the average from 20 to 70 miles for each leg of the journey and exceeding 100 in exceptional cases. Between migrations, however, the daily routine is less strenuous, and the normal cruising distance at these seasons is no greater apparently than that of the whitetail. In the early morning and late evening the deer may be found in meadows and open glades, but at other hours, like the whitetail, they seek out the protecting cover of the forest for resting, although Dixon (29, 30) believes that during the summer they may bed down in open meadows.

In winter the blacktails tend "to congregate in good-sized bands" according to Anthony (*13 g.r.*), but their behavior at this season must not be mistaken for the yarding habit characteristic of the white-tailed deer in the East. True, the formation of bands is due in large part to the restricted area of suitable range, causing the animals to seek out the more favorable situations, but these areas of concentration are much less clearly defined than similar winter habitats of the whitetail, and in no sense can they be regarded as yards. In summer only the bucks occasionally form fair-sized groups up to ten in number, the tendency in both sexes being to pursue their daily routine as individuals or in parties of two or three. The bucks and does do not mingle at this season.

Cover Requirements. Although both the white-tailed and the black-tailed deer are classed as forest inhabitants, neither prefers nor subsists well in stands of old-growth timber; both attain their greatest abundance under conditions of cover characterized by a diversity of types and age classes, which include a small representation of nonforested land and considerable areas of dense young stands and brushland. Ideal range in Leopold's (*66 g.r.*) opinion contains 50 per cent brushland and 25 per cent each of woodland and nonforested land. Stands of reproduction and small saplings are considered as brushland, and all other forested areas as woodland. By this definition the ideal is composed predominantly of young age classes, and only in regions of extensive lumbering operations, recent in origin, are these preferred conditions to be encountered. Even in extensive recently cutover areas such preferred environmental habitat cannot be maintained longer than the dictates of natural succession permit. This is not to be construed, however, as grounds for an assertion that heavy deer populations do not occur in districts having a more nearly normal distribu-

tion of age classes. The foregoing is merely a statement of what appear to be the ideal conditions for maximum populations.

Cover Requirements of the White-tailed Deer. The white-tailed deer is fundamentally a resident of regions in which hardwoods form the dominant vegetation. During pre-Colonial days, for instance, the heaviest populations occurred in the hardwood forests of the Central states. Conifers in moderate amounts are highly desirable, but districts having forests composed primarily of coniferous species support at best only a scattered population and often none at all. In parts of northern New England and southeastern Canada, where formerly the virgin forests ran heavily to spruce and fir, deer were practically unknown until partial removal of the conifers encouraged the establishment of second-growth hardwoods in sufficient volume to render the locality habitable. The absence of deer, however, may have been due to causes other than the composition of the forest. Today, as a consequence of past cutting operations with their resultant change in stand composition, the spruce-fir region supports a fair deer population.

There appear to be no particular forest types that one can call typical summer range. During this season deer may be found in almost any area where relatively undisturbed conditions prevail and food supplies are adequate. The nonforested types such as meadows, open swales, and margins of ponds are frequented most commonly during the morning and evening feeding periods, rarely at other times. Forested cover is preferred during the intervening day and night periods.

For purposes of bedding down and resting, the more open stands, which permit a relatively unobstructed view for some distance, appear to be preferred to denser cover, although this is by no means invariably so. Bedding sites are to be found more commonly near the crest of slopes and knolls than lower down in stream bottoms. This tendency to utilize the cover of higher elevations during the day facilitates escape "over the ridge"; but on the other hand, this choice may be mainly a matter of comfort, since such sites are better ventilated and less thickly populated with insects.

Favored winter cover normally contains a considerable representation of conifers, the evergreen foliage of which affords more concealment and greater protection against cold winds than the open crowns of deciduous hardwoods. Stands of northern white cedar, usually found in swamps or about small ponds, provide a superior winter habitat with respect to both food and cover; such stands are widely used as yarding areas wherever this type occurs extensively. Other swamp types are also frequented at this season, owing probably to the abundance of browse occurring there and to the sheltering effect of surrounding higher lying terrain.

In central New England all coniferous types—but particularly stands of pine—are favored situations for winter occupancy (50). Yarding in

the true sense of the word does not occur in that region, however, and the deer move about considerably from one stand to another, usually in small groups. The animals keep to the conifers in the main, especially at night, and confine their activity to stands of hardwoods mostly during the warmer parts of the day.

FIG. 9·2. Overbrowsed winter deer yard in Minnesota. Overbrowsed winter yards are a common occurrence on the northern range of the eastern whitetail. The condition of overbrowsing is a result of too many deer in a restricted locality. Under these conditions many deer are lost, but the greater damage is to the forage and not to the deer herd. Reduction of the deer herd by hunting is the only solution to the problem of overbrowsing. (*U.S. Fish and Wildlife Service.*)

In central and eastern New York the deer seek south and east slopes during the winter, presumably because of the protection from wind and the higher temperatures on such exposures. From an early fall condition of widely scattered individuals and small groups, the deer congregate in ever-increasing numbers as the winter season advances (21). Cook and Hamilton found that the winter herds increase from 5 to a total of 12 and 15 individuals during January, when the winter snows make travel difficult. But by late February these aggregations increase still more, some having as many as 40 individual animals. The pattern of life under these conditions is to bed down during the day on the upper slopes in fairly dense hardwood and hemlock cover. An hour before sunset the whitetails begin to work out from the timber toward the lower slopes. In New York, as in western Massachusetts, the deer use open rather than dense stands for

bedding, but in locations protected from the wind. Under this condition they are thus in a position to take full advantage of the higher solar radiation intensities, to be well sheltered from the wind, and yet at the same time to be able to observe freely in all directions.

In Pennsylvania winter concentrations occur in the stream-bottom types composed of hemock, laurel, and rhododendron, all evergreen species forming dense cover (40). However, these protected situations are frequented only in periods of unusually cold weather, for during the milder portions of winter hardwood stands are utilized consistently, even on the higher, more exposed slopes. Similar conditions probably prevail in other parts of the range to the south, the evergreen stands or types providing the best cover for use during storms or otherwise severe weather. However, the deer here, as in Pennsylvania, are fairly well dispersed except during periods of particularly inclement weather.

In central Wisconsin, a northern extension of the oak-hickory forest region, the characteristic winter habitats reported by Hamerstrom and Blake (46) are of two main types: (1) pine thickets (mostly jack pine) interspersed with small marshes and swales of willow, aspen, birch, alder, or hazel, and (2) a similar type containing admixtures of pine and oak but otherwise not greatly different. Of the 40 areas of deer concentration studied by these investigators, 35 occurred in situations as follows: 14 in the pine thickets and 21 in the pine-oak mixture. Pure conifers (swamps of black spruce and tamarack) and pure hardwoods (oak interspersed with swales) accounted for the other 5. The average area of deer concentration contained 380 acres, the range varying in size between 50 and 2,600 acres. Sixty per cent of these wintering sites were under 200 acres. The average estimated deer population residing within the 40 areas studied was one deer to approximately 15 acres. Around each area a zone about 1,000 feet wide was used as a feeding ground. In some cases adjacent areas were joined by runways, permitting travel from one to another.[1]

Farther north, in that part of the deer range where snows are deep and the forests are composed chiefly of coniferous species, the areas of deer concentration are often several thousand acres in extent. Here the coniferous swamp is almost invariably present, often being the principal cover type. For example, the larger deer yards in Michigan's Upper Peninsula cover between 10,000 and 35,000 acres, of which commonly half or more is coniferous swamp (74). Northern white cedar, black spruce, balsam fir, tamarack, and alder in various combinations comprise the vegetation of a typical coniferous swamp.

Cover Requirements of Black-tailed Deer. The black-tailed deer, like the eastern whitetail, is characteristically an inhabitant of forest and woodland;

[1] For a complete account of Wisconsin's deer problem see A history of Wisconsin deer. By Ernest Swift. *Wis. Conserv. Dept. Pub.* 323, 1946.

yet its typical habitat bears little resemblance to that of the whitetail, since the forests of the East are mainly composed of hardwoods whereas those in the West contain chiefly conifers.

In summer the blacktail will be found on the upper slopes of the ridges where it has migrated from its winter range below during the spring. Typical summer range consists of subalpine forests and the upper reaches of the montane forests lying just below. Both of these forest types are interspersed with mountain meadows and rocky ridges and shoulders. Although the forests differ in composition from one geographical locality to another, they contain conifers in the main, particularly such species as Englemann spruce, alpine and white firs, Douglas fir, and lodgepole pine in the Rocky Mountains, and red fir, white fir, mountain hemlock, lodgepole pine, and whitebark pine in the Sierra Nevada Mountains. Groves of aspen, not uncommon in the Rockies, comprise the principal hardwood component. These are the altitudinal belts characterized by vegetation of the Hudsonian, Canadian, and upper-transition zones.

During the early morning and evening the deer will be seen feeding in mountain meadows, but during the rest of the day they customarily retire to wooded cover. It is quite probable, however, that open areas such as these meadows and forested glades are frequented by blacktails more freely and for longer periods of time in summer than during the winter and to a considerably greater extent at all seasons than in the case of white-tailed deer. The latter animal avoids nonforested types except when feeding, and even then it rarely leaves the woodland fringe by more than a few rods. The blacktail, on the other hand, seems less wary in this respect. As an example, the blacktail will bed down at night in open meadows, but the whitetail will not.

Winter range is found at lower elevations where the weather is more congenial and the vegetation characteristic of the lower-transition and Upper Sonoran zones. Forests of ponderosa pine and Douglas fir and open woodland containing piñon pines and western junipers typify the usual winter habitat in the Rocky Mountain region. In the Sierra Nevada the habitat includes forests of white fir and ponderosa, Jeffrey, and sugar pines, which occur on the lower mountain slopes, and the zerophytic oak woodland and chaparral of the foothills.

The upper limits of the winter range are clearly defined by snow depth according to Russell (68). Snow conditions permitting, many of the deer prefer to remain in the forested sites and enter the brushy types to no great depth unless it is necessary.

Food. The deer is a ruminant. As with all ruminants, its diet is chiefly vegetable materials, consisting of browse, a wide assortment of herbaceous foodstuffs, and certain kinds of fruit when available. The first two categories supply by far the bulk of the food consumed, with browse being the

principal staple in winter, augmented by herbaceous materials at other seasons. By browse is meant the leaves, buds, twigs, and bark of woody plants. In regions having extensive oak forests and where heavy accumulations of snow do not prevent, acorns supplement the fall and winter diet in years of large seed crops. Mast is eaten most freely in the autumn; if deep snow covers the crop during the winter, it again becomes available the following spring. Oak and beech are the two main mast-producing trees.

At other seasons during the period of vegetative growth, the diet contains a high percentage of vegetable foods of all kinds: the leaves of woody plants, grasses, and other herbaceous materials in abundance. Browsing on bark and woody twigs continues throughout the year, but to a lesser degree during the growing season, since the leafy product of the current season's growth assumes a priority position in the food diet. Feeding during the summer months is a combination of browsing and grazing; the latter commences in the spring with the first appearance of lush new grasses and other herbs and continues into the autumn as long as their palatability is retained.

As with so many other game animals, winter is the critical time in the life of the deer with respect to its food requirements. During other seasons the abundance and variety of food materials ensure a continuous supply of nutriment more than adequate to meet any contingency in all but rare instances. But winter presents a far different condition. Fewer and less nutritious foods are then available. Continued cold and constant high winds, in particular, lower body temperatures, thereby placing a greater strain upon the processes of metabolism and demanding more in the way of energy-producing nourishment. And most damaging of all—as the result of the tendency to concentrate in yarding areas of limited size and carrying capacity—virtually the entire deer population is congested into a relatively small portion of the total range and is compelled to subsist there as best it can. An example from Pennsylvania is a case in point. In December [1] 70 deer in one area under study were making full use of a range of 1,035 acres. By February, however, these same animals occupied a single concentration area comprising but 110 acres, or some 11 per cent of their summer range (42). It is clearly evident that the health and vigor of a herd cannot long be maintained under such circumstances. Therefore it is not surprising that the smaller and weaker animals thus "imprisoned" not uncommonly succumb to starvation when confinement is for a protracted period and that even the larger and more vigorous animals normally lose weight at this season. In fact, loss of weight during the winter is probably characteristic of most deer, whether congested in yarding areas or not.

[1] The article by Gerstell (42) does not give the year to which these data apply but states that the field study was made "several years ago"

The food requirements of both sexes not only vary with the climatic seasons but depend in part upon the sexual cycle. For males, the drain upon vitality is greatest in winter and during the rut; for females, during the later stages of pregnancy, which include winter, and the few weeks following parturition when the fawns are being suckled. The relationship among different seasons of the year, type of activity, and feeding habits of male and female deer are summarized as follows:

Period	Male	Female
Breeding season	Activity greater than at any other season; feeding intermittent and irregular, accompanied by loss in weight	Less affected than the male by mating activity; feeding habits normal; weight relatively constant
Early winter	A period of recuperation: activity normal; feeding heavy; some lost weight regained	The early stages of pregnancy: feeding activity normal; gradual increase in weight
Winter	A period of unusual hardship placing a great strain upon metabolic processes; feeding heavy if the usual deficient food supply permits; loss in weight frequently great; starvation not uncommon, particularly for small individuals on overbrowsed range	Exposed to the same hardships as the male, but in general subject to more acute suffering, particularly for smaller individuals
Spring	Activity normal; feeding heavy; weight increases; new antlers develop; food supply no longer deficient	Pregnancy in advanced stage; feeding heavy; weight increases
Summer	Activity less than usual; food consumption slackens as weight is regained and antlers mature	The period of parturition and nursing of the young: places heavy drain upon strength and vitality, weight decreases during early stages despite active feeding
Early autumn	Activity and feeding increase; weight remains relatively unchanged	A period of recuperation: weaning complete; feeding heavy; lost weight regained

From evidence afforded by controlled feeding experiments conducted in various parts of the country, it is apparent that the *basic daily feeding ration* required to maintain vigor and health depends upon the nature of the ration, the size of the individual, and the time of year. Results thus far published are not sufficiently comprehensive to permit detailed discussions concerning these points, but certain of the findings are noteworthy. In Michigan deer fed exclusively on northern white cedar remained vigorous throughout the winter on a daily ration of 4.5 pounds per animal per day. Maintenance of vigor on mixed rations containing browse of several species, both conifer and hardwood, required around 7 pounds per day (24, 25, 26,

27). In Arizona a daily ration of 2.2 pounds (air-dry weight) per hundredweight of deer proved satisfactory for Rocky Mountain mule deer and Coues whitetails (63). The basic requirement was the same for native forage or a diet of domestic foodstuffs. In terms of forage in its natural succulent condition, the air-dry weight should be approximately doubled.

The carrying capacity of a range, measured in terms of food availability, depends upon two factors: stand age and stand composition. These factors apply with particular emphasis to winter conditions, when the nature and volume of browse are of the utmost importance. In general, browse is more abundant in young well-stocked stands, reaching its greatest volume a few years after cutting operations, when the new stems are perhaps head high. Thereafter its value deteriorates. The effect of stand age can be amply demonstrated by direct measurement, which has been done in a number of cases. Gerstell (42, 43, 44) states that the supply of browse in a young hardwood stand of the age just described frequently exceeds 200 pounds per acre, whereas in similar but older stands it is no more than 25 pounds per acre. As another example, Aldous (1) has shown that a stand of northern white cedar 8 feet high compares favorably with taller stands as to content of browse and surpasses them in the ability to replace browsed-off branches. A Lake states forest experiment station publication (7) indicates that the browse of white cedar trees (portion up to 7 feet high) is greatest for trees from 3 to 5 inches in diameter, having a total of 4.5, 4.1, and 3.5 pounds of browse, respectively. The browse for entire trees ranged from 0.3 pound per tree for trees ¼ inch in diameter at breast height up to 74 pounds per tree for trees 12 inches in diameter at breast height.

Turning now to the effect of stand composition, it is at once evident that here is a complex subject—complex in that the range of the deer is so extensive and encompasses so many forest types and regions that any consideration of food preferences must of necessity be treated from a local point of view. Except for certain localities these considerations have received little detailed study. The U.S. Forest Service has made a very careful study of deer yards in the Chequamegon National Forest in Wisconsin (5). The results show a variation in the amount of deer browse available ranging from as high as nearly 2 tons of browse of all kinds per acre in good swamps to as low as 75.2 pounds per acre on browsed-out areas. From these data U.S. Forest Service has developed a conversion table of available browse by species after the winter yards had received varied degrees of browsing. This conversion table was then used in connection with a deer yard survey to determine the amount of winter food available on a pound-acre basis. With such information and a knowledge of the amount of food needed to maintain a deer per unit of time (23) it is easy to calculate the carrying capacity of each swamp or of all the wintering areas in a particular locality.

Food Habits of the White-tailed Deer. White-tailed deer have been described rather aptly as "random tip browsers," plucking at a "twig here and a leaf there in an apparently thoughtless and unsystematic manner" (34, 35), but nevertheless the variety of foods thus consumed is enormous. Atwood's (9) compilation of deer foods, gleaned from published literature, lists 614 species of plants eaten by deer. Doubtless there are still others as yet not recorded. For obvious reasons, therefore, further discussion will be limited to the plants that are most frequently ingested. Only the winter diet will be considered, this being the critical factor most likely to limit deer-population density. The diet in summer is too varied to be susceptible of detailed treatment on the basis of information now available. That it consists of woody browse to a limited extent and practically anything green and succulent seems reasonably evident.

To determine the relative palatability of different food material, either one of two methods may be adopted: (1) feeding experiments, in which captive animals are fed an assortment of the materials to be tested and their likes and dislikes thus established by observation or comparative measurements of consumption, or (2) field studies based on an examination of browsed plants, plus direct observation of feeding animals. The food preferences of the deer have been studied by both procedures, though less extensively by the first method than is desirable considering the variety of edible plants indigenous to different parts of the range.

Table 39 presents the results of three such studies. The arrangement of plants in each list is that of the recorded authority, and the order within each preference class has no significance except in the preferred group for Massachusetts. In that case the authors attempted to arrange the preferred materials only in their approximate order of importance. It is perhaps well to state that too literal an interpretation of the table is not warranted. Discrepancies exist, and in certain respects the tables are not comparable. However, if these limitations are borne in mind, they should not detract seriously from the over-all impression that the table is meant to portray.

In Ohio the most important winter food plants, according to Chapman's listing (19), are chestnut oak acorns, corn, apple, dogwood, hazelnut, mountain laurel, dwarf sumac, blackberry, greenbrier, and orchard grass, roughly in that order. This was formerly an agricultural region. Forests cover but 25 per cent or less of the total land area, and in composition they are typically hardwood. Unlike Michigan, New York, and northern New England, the habitat in Ohio is "Southern" in nature.

Deer herds have developed in some of the Eastern states on forest lands that have a low value at present in so far as they relate to the production of ordinary forest products. For example, Bramble and Goddard (14) point out that Pennsylvania has over 2 million acres of land known as the

TABLE 39. IMPORTANT FOOD PLANTS IN THE WINTER DIET OF THE NORTHERN WHITE-TAILED DEER AS SHOWN BY CERTAIN STUDIES AND OBSERVATIONS

New York (57) Basis: feeding experiments	New York (65) Basis: field observations	Massachusetts (50) Basis: stomach analyses and field observations
	Preferred Materials	
Northern white cedar	Round-leaved dogwood	Apple (fruit)
Black birch	Staghorn sumac	Dwarf raspberry
Yellow birch	Flowering dogwood	Ground hemlock
Staghorn sumac (fruit)	Basswood	Wintergreen
Sweet fern	Apple	Red maple
Witch hobble	Witch hobble	Black cherry
Ferns (many species)		Hemlock
		Hazel
		Staghorn sumac
		Red oak
	Materials Readily Eaten	
Apple	Red maple	White oak
Mountain ash	Sugar maple	Poplar
Balsam fir	Striped maple	Mountain maple
Basswood	Witch hazel	Striped maple
Paper birch	Birch	Sugar maple
Wild raisin	Oak	Apple (browse)
Red cedar	Large-toothed aspen	Wild raisin
Black chokecherry	Trembling aspen	White ash
Elderberry	Maple-leaved viburnum	Hickory
Ground pine		Chestnut
Hazel		Shadbush
Honeysuckle		Black birch
Common juniper		Yellow birch
Red maple		Witch hazel
Striped maple		Dogwood
Red-ozier dogwood		Mountain laurel
Raspberry		Partridgeberry
Staghorn sumac (browse)		Spiny-shield fern
Canada yew		Sorrel
Hemlock		Fungi

scrub or bear oak type of "barrens" (*Quercus ilicifolia* Wang.), which has a low value for wood products but produces deer abundantly. A study of the seasonal use of the plant materials in this type used by deer for food disclosed that sweet fern and prairie willow were utilized most heavily in the critical periods of winter and spring. Other species utilized heavily in winter when other foods are scarce were trembling aspen, dwarf gray willow, chokeberry, and bear (scrub) oak. New Jersey tea, hawthorn, and

Allegheny plum were used most heavily in summer, and New Jersey tea most heavily in the fall. On the sample areas studied, deer were present to the extent of about one deer for 20 acres.

One of the few year-round food studies for white-tailed deer is given for the Black Hills region of South Dakota by Hill and Harris (49). A condensed summary of the findings of this investigation is given in the following table.

This study is significant in that it gives the food for white-tailed deer for the entire year by seasons. Bearberry and Oregon grape are outstanding foods during both fall and winter, while wild rose, aspen, and grasses appear to be the most universally used as summer foods.

Preferred browse species reported by Stegeman (72) in the Pisgah National Forest in North Carolina were basswood; chestnut; sourwood; flowering dogwood; striped maple; scarlet, black, and red oaks; red maple; and black locust of the trees species; and mountain pepper bush, wild grape, greenbrier, saw brier, witch hazel, and fetterbush among the shrubs. Certain of these species, basswood, for example, had a low forage value because of their limited occurrence. Stegeman considers the relative importance of shrubs and vines, trees, and herbs and grasses to be in the relation of 8:4:1.

Unfortunately, palatability is not a reliable measure of relative nutritive value, for certain readily eaten materials are entirely inadequate as a sustaining diet. This fact is well authenticated by feeding experiments of the type previously mentioned. From the published results of these studies several conclusions seem clearly demonstrated. (1) Certain materials are highly nutritious, whereas others are comparatively worthless, being little better than "stuffing food." (2) Certain of the less nutritious plants comprise a satisfactory ration if eaten in sufficient quantity and in combinations that give variety. For instance, it appears from experiments in Michigan that a number of common and reasonably palatable browse species are unsatisfactory when fed individually to the exclusion of all others, but fed in combinations as a mixed diet they seem to be entirely adequate (25). One explanation of this seeming paradox may be that the mixed ration is consumed in greater quantity because of its variety.

Of the more commonly browsed species, northern white cedar is unquestionably the most nutritious and is one of high palatability (25, 57). Oak acorns and beech mast are almost equally desirable. Materials of low nutritive value quite incapable of sustaining health and vigor include marsh hay, balsam fir, and the various pines. Hemlock, though probably somewhat superior to balsam as browse, is not a sustaining ration. Hardwood browse is of a still higher dietary value and, if consumed in considerable bulk, provides an acceptable diet. Of the more common species, yellow and black birch are perhaps the best. Oak browse is poor; aspen

TABLE 40. STOMACH CONTENTS OF 79 BLACK HILLS WHITE-TAILED DEER (49)

Plant species	January–April (17 deer)		May–September (8 deer)		October–December (54 deer)	
	Frequency, per cent *	Volume, per cent †	Frequency, per cent *	Volume, per cent †	Frequency, per cent *	Volume, per cent †
Browse species:						
Bearberry (*Arctostaphylos uva-ursi*)	71	23.8	..	..	76	15.3
Ponderosa pine (*Pinus ponderosa*)	59	11.1	25	0.1	15	1.8
Buckbrush (*Symphoricarpos occidentalis*)	59	10.1	62	1.8	50	9.9
Oregon grape (*Odostemon repens*)	41	6.7	25	0.4	69	15.0
Wild rose (*Rosa* spp.)	47	6.2	100	22.2	46	2.6
Serviceberry (*Amelanchier* spp.)	59	5.6	50	2.9	41	1.9
Snowbush (*Ceanothus velutinus*)	6	2.6	12	Trace	28	4.0
Bur oak (*Quercus macrocarpa*)	53	2.5	..	....	..	0.3
Aspen (*Populus tremuloides*)	12	1.8	62	21.0	30	0.3
Creeping juniper (*Juniperus horizontalis*)	18	1.5				
Willow (*Salix* spp.)	24	1.3				
Other browse species (20)	..	2.2	..	7.2	..	13.0
Total	..	75.4	..	55.6	..	61.1
Weed species:						
(Unidentified)	82	3.0	100	24.5	85	12.1
Everlasting (*Antennaria* spp.)	24	2.9	..	....	48	6.3
Pasque flower (*Pulsatilla ludoviciana*)	6	2.6	12	1.1		
Water hyssop (*Bacopa rotundifolia*)	12	0.1	..	....	4	1.1
White clover (*Trifolium repens*)	..	....	12	Trace	30	3.1
Sweet clover (*Melilotus* spp.)	..	....	..	....	6	1.2
Other weed species (14)	..	Trace	..	0.8	..	1.3
Total	..	8.6	..	26.4	..	25.1
Grass species:						
Grasses (mostly *Poa*)	76	7.0	88	12.0	76	3.3

* Percentage of occurrence of individual plant species.
† Percentage of total stomach contents.

Plant species	January–April (17 deer)		May–September (8 deer)		October–December (54 deer)	
	Frequency, per cent *	Volume, per cent †	Frequency, per cent *	Volume, per cent †	Frequency, per cent *	Volume, per cent †
Grass species (*cont.*)						
Wheat (*Agropyron triticum*)	18	5.6	. .	. . .	2	0.6
Oats (*Avena sativa*) . . .	6	0.1	12	1.9	13	3.8
Corn (*Zea mays*) . . .	6	0.1	. .	.	6	2.3
Barley (*Hordeum vulgare*)	. .	. .	. .	.	7	0.6
Total	. .	12.8	. .	13.9	.	10.6
Old-man's-beard (*Usnea* spp.)	24	2.9	. .	. . . .	31	1.1
Fungi (unidentified)	. .	. . .	62	4.0	31	2.1
Total for fungi and lichens species	.	2.9 ‡	. .	4.0 ‡	. .	3.2

* Percentage of occurrence of individual plant species.
† Percentage of total stomach contents.
‡ Total of these percentages does not equal 100 Data given as published

and the maples are fair. Timothy hay is not satisfactory. Alfalfa appears excellent in some experiments but unsatisfactory in others (18). It must be fed in quantity, however, for only the more choice parts are eaten, the stems and coarser materials being left untouched by white-tailed deer.

Recent experiments with deer in fenced plots in Michigan have contributed several valuable facts in relation to deer management (28). The first of these relates to the actual carrying capacity of deer per acre in deer yards of different cover composition. Davenport and his assistants state that good coniferous winter deer yards during the years of their maximum browse availability, *i.e.*, those having a goodly amount of northern white cedar in the mixture, will carry two to three deer per acre on a sustained basis.

The second fact concerns the stand composition of the deer yards. For instance, actual analysis of what appeared to be a pure stand of swamp conifers showed a maximum of 8,680 stems per acre, of which 38.0 per cent was white cedar, 41.5 per cent speckled alder, 15.2 per cent palatable hardwoods, and 5.3 per cent balsam fir and spruce. Hardwood yards will usually carry less than one deer per acre. One hardwood plot tested contained 13,980 stems per acre, 88 per cent of which was hard maple and 12 per cent other northern hardwoods.

The third valuable fact in relation to winter deer-yard carrying capacity is that yards will carry proportionately more deer for longer periods if the

number of deer present are below the sustained capacity of the yard to maintain them.

Food Habits of the Black-tailed Deer. Knowledge of this phase of black-tailed deer ecology has not benefited by intensive study to a degree commensurate with that of whitetails, but information is by no means lacking. The evidence thus far published suggests that the black-tailed deer, although a consistent browser, secures a significant part of its diet by grazing, since grass is usually abundant, notably so on its summer ranges. In this respect the deer differs from eastern deer, which graze, to be sure, but less extensively. The principal browse plants are trees, both deciduous and evergreen, some of which are microphyllous. By virtue of their abundance oaks are among the more important of the tree species. Conifers, though utilized on occasions, particularly in winter when shrubby plants are snow covered, appear to be less favored than other plants.

As one might expect, in view of the varied habitats frequented by the blacktail, feeding habits on different sections of the range show little uniformity as concerns principal food materials. By way of illustration, the following paragraphs are devoted to a consideration of four black-tailed deer food-habit studies, each in a distinctly different part of its range· Arizona (63), California (29, 30, 31, 68), Wyoming (68), and Oregon (20).

In Arizona, which may be regarded as typical of the *southern Rocky Mountain region,* Nichol tested the palatability of 168 species of native forage plants. Tests were run on the Rocky Mountain mule deer and the Arizona whitetail. Both species exhibited similar preferences. On the basis of this study it appears that three trees are of outstanding food value: aspen, madrona, and mountain hackberry, particularly the first. Less preferred but of considerable importance are mulberry, ash, walnut, and cherry. The oaks, despite their lower palatability, constitute an important food item because of their widespread occurrence and the fact that many species because of their evergreen foliage are available as browse at all seasons. The principal representatives of this group are Emory oak, Mexican white oak, and Utah (Gambel's) oak. The position held by conifers as a source of food is well described in the following statement by Nichol (63):

> Early in the work it was discovered that the deer reacted to the coniferous group rather as a conditioner or a condiment than a regular food. This reaction held throughout the study. When fir, spruce, pine, or piñon was offered to the deer (nonconiferous species were available also), they might make an entire meal of any one of these plants, which would be ignored again for 10 days or 2 weeks, and then another meal would be made from either the same species or another one. Within the limits of our work and observation we were led to consider these plants as valuable ingredients in the forage ensemble which furnished needed tonics, enzymes, or vitamins rather than the necessary fats, carbohydrates, and proteins.

Of the junipers only the alligator juniper appears to be of value. When other species are browsed, it is evidence of overgrazing.

The shrubs of outstanding importance in this region are bouvardia, cat's-claw, fendlera, grape, false indigo, false mesquite, mesquitillo, mimosa, mistletoe, buckwheat, and buckbrush (*Ceanothus*). The last three are evergreen. Although normally deciduous, certain of the legumes, particularly mesquitillo, often bear persistent foliage if growing on slopes of southern exposure. For this reason mesquitillo is an important winter food. Nichol regards buckwheat (*Eriogonum wrightii*) as the most valuable single food plant among the shrubs because of its year-round availability and wide occurrence.

As elsewhere, herbaceous materials are eaten in quantity and in great variety during the vegetative season. Of the 16 species of grass and 68 herbs tested by Nichol, 11 of the former (especially knotgrass and slim triodia) and 23 of the latter are considered important. These important food plants are available in the succulent state from April through September.

Northward, in the *central and northern Rocky Mountains*, conditions are more rigorous than in the region just described, and the native flora lack many of the broad-leaved evergreens typical of the warmer and more arid climate to the south. The principal food plants, therefore, are somewhat different from those encountered in Arizona. The more important browse species of the region, based on Russell's observations (68) in the Yellowstone region of Wyoming, are listed in Table 41. Spring grasses usually commence growth in April, marking the close of winter, and it is then that the spring deer migration to the summer range begins. At this season the new grasses form an important part of the diet; and as these plants start development at successively higher altitudes, the deer herds move upward at a corresponding pace, reaching their summer habitat in late May or early June. By September vegetative growth ceases, plants assume their autumnal character, and the downward migration to lower elevations is soon under way.

In the Blue Mountains of eastern Oregon, the most important browse plants according to Cliff (20) are butterbrush (*Purshia tridentata*), mountain mahogany (*Cercocarpus ledifolius*), western juniper (*Juniperus occidentalis*), and snowbrush (*Ceanothus velutinus*). As reported by this investigator, these species comprised 30, 20, 12, and 8 per cent, respectively, of the diet.

Westward, on the *Pacific slope of the Sierra Nevadas*, the prevailing conditions are unlike those in the Rockies, and the vegetation there reflects the more congenial climate of that area. Deer in this region are not forced to contend with the severe winters typical of the northern Rockies and the eastern flanks of the Sierra Nevadas, and by comparison their winter habitat is more nearly ideal. The typical brushy cover afforded by the

TABLE 41. PRINCIPAL BROWSE PLANTS IN THE DIET OF THE ROCKY MOUNTAIN MULE DEER AS SHOWN BY CERTAIN FEEDING EXPERIMENTS AND OBSERVATIONS

Arizona (63) Feeding Experiments	Wyoming (68) Observations
Winter Browse	
Aspen	Aspen
Buckbrush	Rocky Mountain cedar
Buckwheat	Chokecherry
Cliff rose	Squaw currant
Madrona	Sticky currant
Mesquitillo	Wild gooseberry
Mistletoe	Limber pine
Mountain mahogany	Rabbit brush
Arizona oak	Rose
Emory oak	Sagebrush
Mexican white oak	Western serviceberry
	Snowberry
	Willow
Summer Browse	
Arizona ash	Aspen
Aspen	Canadian buffalo berry
Brickellia	Red-ozier dogwood
Bouvardia	Elderberry
Buckwheat	Red raspberry
Cat's-claw	Redroot (tobacco brush)
Cherry	Willows
Elk clover	
Fendlera	
Grape	
Desert hackberry	
Mountain hackberry	
False indigo	
Lemonbush	
False mesquite	
Mesquitillo	
Mimosa	
Mulberry	
Nogal (walnut)	
Utah oak	

chaparral types provides food in abundance, and the mild weather at lower altitudes is less detrimental to the health of the overwintering animals. Grasses, which are rarely available as forage in the Rocky Mountains or the Great Basin between September and April, commence growth in the Sierras with the first winter rains and are already several inches high by late December. Thereafter they contribute to the winter diet wherever snow is of infrequent occurrence. As winter browse, the well-nigh ubiquitous chaparral, with its many palatable species, ensures an adequate food supply under all but the most abnormal circumstances. In summer, forage

is always ample. Dixon's (29, 30, 31) estimate of the more important food plants in California, based on 30 years of study and observations, appears in Table 42.

TABLE 42. THE MORE IMPORTANT FOOD PLANTS IN THE DIET OF THE CALIFORNIA MULE DEER (29, 30, 31)

Common name	Scientific name	Parts eaten *	Season of greatest use †			
			W	*S*	*S*	*F*
Trees:						
White fir	*Abies concolor*	*L, T*	..	..	..	x
Pacific serviceberry	*Amelanchier florida*	*L, T, F*	..	..	..	x
Curly-leaf mountain mahogany	*Cercocarpus ledifolius*	*L, T*	x			
Testota	*Olneya testota*	*L, T, F*	x			
Ponderosa pine	*Pinus ponderosa*	*L, T*	x			
Trembling aspen	*Populus tremuloides aurea*	*L, T, Sh*	..	..	..	x
Honey mesquite	*Prosopsis juliflora glandulosa*	*L, T, F*	..	..	..	x
Western chokecherry	*Prunus virginiana demissa*	*L, T, F*	..	..	..	x
Bitter cherry	*P. emarginata*	*L, T, F*	..	..	..	x
California scrub oak	*Quercus dumosa*	*L, T, F*	x			
California black oak	*Q. kelloggii*	*L, Sh, F*	x			
Huckleberry oak	*Q. vaccinifolia*	*L, F*	..	..	..	x
Velvet elder	*Sambucus velutina*	*L, F, Fl*	..	..	x	
Shrubs:						
Green manzanita	*Arctostaphylos patula*	*L*	x	x		
Snowbrush	*Ceanothus cordulatus*	*L, T*	..	..	..	x
Buckbrush	*C. cuneatus*	*L, T*	x			
Deer brush	*C. divaricatus*	*L, T*	x			
Deer brush	*C. integerrimus*	*L, T*	..	..	..	x
Creek dogwood	*Cornus californica*	*L, T*	x	x	x	x
Antelope brush	*Purshia tridentata*	*L, T*	x			
Nevada currant	*Ribes nevadense*	*L, F*	..	..	..	x
Gooseberry	*R. roezlii*	*L*	..	..	..	x
Thimbleberry	*Rubus parviflorus*	*L*	..	..	x	
Herbs and grasses:						
Wild oat	*Avena fatus*	*B*	x	..	..	x
Common mustard	*Brassica campestris*	*L, S*	..	..	x	
Tall buckwheat	*Eriogonum nudum*	*S, Fl*	..	..	x	
Filaree	*Erodium botrys*	*L, S*	x			
Meadow fescue	*Festuca elatior*	*B*	x	x	x	x
Spanish clover	*Lotus americanus*	*L, S*	..	..	x	
Bur clover	*Medicago hispida*	*L, F*	..	x		
Evening primrose	*Oenothera hookeri*	*L, S*				
Kentucky bluegrass	*Poa pratensis*	*B*	..	..	x	
Yard grass	*Polygonum aciculare*	....	..	..	x	
Curly dock	*Rumex crispus*	*L, S*	..	..	x	

* *B*, blades (grass); *F*, fruit; *Fl*, flower; *L*, leaves; *S*, stem; *Sh*, new shoots; *T*, twigs.
† Winter, spring, summer, fall.

Water and Mineral Requirements. Water and salt requirements are strongly influenced by temperature, the rate of evaporation, the type and moisture content of food materials, and the weight, condition, and activity of the deer. Both moisture and mineral requirements are greater in summer than in winter and increase as the air becomes warmer and drier. As an example of the seasonal variation, Nichol (63) estimates that the average water consumption under Arizona conditions is 1 to 1½ quarts per day per hundredweight of deer in winter and twice that volume in summer. Large or active animals require more than others, and pregnant does require more than barren does.

The need for water in the free state appears to be at least partially offset by the consumption of succulent foods. In this connection mule deer are said to be capable of subsisting for several days at a time without water if succulent materials are available in abundance (*66 g.r.*), but whether or not the whitetail possesses similar capabilities is not known. Chapman (19) reports that whitetails observed in Ohio were never seen to drink anything but brackish water about salt licks. In any event, the normal habitat of the white-tailed animal is so well supplied with streams and ponds that enforced abstinence of a serious nature probably seldom occurs. Snow is also a satisfactory substitute for water (57).

Minerals are supplied in part by the normal diet of vegetable matter and in part by natural or artificial salt licks. Natural licks are common in parts of the West and are also found in the East, though less frequently. Artificial licks are generally to be found around logging camps, camp sites, and similar locations. The average monthly consumption, according to Nichol (63), is 1/10 pound per animal in summer and half that amount in winter. Deer in Ohio are frequently observed at licks in the summer but not in winter, no use being made apparently of either natural or artificial salt sources from October to April (19).

Population Density. The density of deer populations is dependent primarily upon the carrying capacity of winter ranges; and as stated earlier, winter carrying capacity for deer is a function of the food supply. Overbrowsed winter range is a sure indication that the population density exceeds the desirable maximum. Wherever this condition exists, the loss from starvation is an ever-present menace.

The importance of winter carrying capacity is clearly evident in the relationship between summer and winter ranges. For example, in the Upper Peninsula of Michigan the acreage encompassed by winter areas of deer concentrations is estimated to be just over 8 per cent of the total summer range (11). In the Lower Peninsula similar average is placed at slightly in excess of 3 per cent, while for the Chequamegon National Forest in Wisconsin (69) it is estimated to be 6 per cent. If it is assumed that the major part of the summer deer populations winter over in these limited

areas, the hardships that ensue from such congested conditions are easily imagined. On the basis of these data, wherever yarding is the customary winter behavior, a tenfold increase in population density during this season seems not at all improbable. In fact, Bartlett (11) assumes this to be the situation in the Upper Peninsula. The winter population in that region averages about 180 animals per square mile, and in certain over-populated yards the population is estimated to be as high as 2,000 per square mile, or roughly three deer per acre. In the Chequamegon National Forest just referred to, reported concentrations varied from 350 to 1,500 per square mile. A typical figure for congested areas in Pennsylvania is one deer for each 1½ acres (40).

From the foregoing it may be properly inferred that the deer population on the summer range is neither so dense as in winter nor so significant in its relation to principles of management. Doubtless there are local examples of overcrowding at this season, but in general the carrying capacity of summer range is ample.

As one might expect, the deer population is not evenly distributed throughout its range.[1] In the East the heavier concentrations occur in Wisconsin, Michigan, and Pennsylvania. Other Northern states from Minnesota to Maine are close competitors, but southward generally lighter populations prevail except in certain isolated localities, such as the Pisgah district of North Carolina in the southern Appalachians. In the West the Pacific slope is probably more densely populated with deer than the Rocky Mountains.

Although local concentrations of more than 200 deer per section (1 square mile) have been reported (11), it is not likely that the average density over broad tracts such as a county or a National Forest ever exceeds 50 animals per section. In Michigan the estimated deer population in 1938 was 16 per section for the Upper Peninsula and 42 for the Lower Peninsula (12). The total herd was placed at nearly 1 million. Comparable values for four subdivisions of Wisconsin's range were 18, 20, 34, and 42 deer per square mile, based on census drives just prior to 1939 (73). In Minnesota, the estimated average for 1939 was 14 per square mile (60). The deer populations in 1940 in several National Forests selected at random are shown in Table 43.

The western range appears to be less productive than the eastern range, since population densities in excess of 20 deer per section occur only under the most favorable circumstances. The average number of deer per section of typical California habitat is about 5 according to Dixon (29, 30). Examples of dense deer populations are shown in Table 44.

[1] That this is true even in as small a unit as a state has been proved by Glen H. Morton and E. L. Cheatum. 1946. Regional differences in breeding potential of white-tailed deer in New York. *Jour. Wildlife Mangt.* **10**(3):242–248.

TABLE 43. THE POPULATION OF WHITE-TAILED DEER ON CERTAIN NATIONAL FORESTS, 1940 (8)

State	National Forest	Gross area, acres	No. of deer	Acres per deer	Deer per square mile
Minnesota	Superior	2,871,000	50,000	58	11.1
Wisconsin	Nicolet	986,000	42,000	23	27.3
Michigan	Ottawa	1,743,000	67,000	26	24.6
Pennsylvania	Allegheny	739,000	30,000	25	26.1
Vermont	Green Mountain	581,000	4,900	119	5.4
New Hampshire	White Mountain	802,000	1,300	617	1.4
Virginia	George Washington	1,578,000	3,000	526	1.2
North Carolina	Pisgah	1,178,000	6,700	176	3.6
Missouri	Clark	1,972,000	2,300	857	0.7
Arkansas	Ozark	1,233,000	4,100	301	2.1
Texas	Davy Crockett	394,000	3,000	131	4.8

MORTALITY

Losses Due to Starvation, Predation, and Miscellaneous Causes. Mortality from causes other than hunting is subject to great variation. It depends in a large measure upon three factors: (1) the population density with respect to range carrying capacity, (2) the severity of the winter season, and (3) the number of predators, a factor that appears to be closely related to the degree of settlement. It is apparent, therefore, that the rate and causes of mortality exhibit marked differences from one region to another as well as among localities within a region. When deer herds are allowed to multiply in numbers beyond the carrying capacity of the range, death from malnutrition and related causes is severe, not uncommonly exceeding even the loss due to hunting. Likewise, wherever dense deer populations occur in districts having severe winters, starvation is an ever-present menace to the overwintering animals, particularly to fawns and weaker individuals. This factor alone accounts for an estimated annual loss of 10,000 animals in the Upper Peninsula of Michigan, which amounted to 16.5 deer per square mile of winter yard during the season of 1937–1938 (11). Locally, the death rate ran as high as 60 deer per square mile, and the aggregate loss was about two-thirds of the legal hunting take. In the Superior National Forest in Minnesota, the winter death toll has surpassed the hunting take in some years (36). In that forest during 1937–1939 the average loss per square mile of yard was 11 deer. For the more heavily populated portions of the northern whitetail's range these are perhaps representative figures. Southward, the threat of starvation becomes progressively less owing to the less restrictive effects of severe winter weather.

TABLE 44. THE POPULATION OF BLACK-TAILED DEER IN SELECTED NATIONAL FORESTS HAVING DENSE POPULATIONS, 1940 (8)

State and National Forest	Gross area, acres	No. of deer	Acres per deer	Deer per square mile
California:				
Modoc.	1,908,186	41,000	47	14
Sierra.	1,459,330	38,000	38	17
Oregon:				
Fremont	1,767,856	24,000	74	9
Malheur.	1,274,837	46,000	28	23
Colorado:				
Gunnison.	1,363,105	27,000	50	13
White River.	918,181	36,000	25	25
Utah:				
Dixie.	880,034	25,000	35	18
Fishlake.	1,524,000	50,000	30	21

However, starvation is not the only decimating effect of malnutrition. Directly or indirectly, dietary deficiencies are responsible for other losses that, if less spectacular, are nevertheless significant in the aggregate, even though they defy accurate measurement. For one thing, seriously underfed animals lack the stamina and alertness to cope with their enemies, and doubtless many of the weaker individuals fall prey to predation or attack of parasitic organisms. Then, too, the number and size of the fawns that a female bears appear to depend in part upon the vigor of the mother. Does suffering from undernourishment are said to produce fewer multiple births, and more females than males may result (39, 42, 43, 44). The offspring, commonly small to begin with, often develop subnormally. All of these factors influence the rate of increment of the deer herd.

The black-tailed deer is also subject to winter losses, particularly in the Rocky Mountain region. In many districts where populations are increasing rapidly, the carrying capacity of winter ranges is already taxed to the limit. In some localities the "deer problem" is so acute that emergency winter feeding is being resorted to but with unsatisfactory results. Carhart (18) cites specific cases in Colorado in which losses in deer yards were heavier where the animals were fed ground alfalfa and stock food than where no feeding was resorted to at all.

The extent of *losses due to predators* is not easily gauged, but such losses unquestionably occur wherever deer are found, though not uniformly so throughout the range. In heavily forested sections that border on being a true wilderness, predation is doubtless a factor of considerable importance. Settlement has penetrated but sparingly into such areas, and the number of carnivores capable of dispatching a deer may be considerable. The prin-

cipal offenders in such wilderness sections are timber wolves and bobcats in the East and mountain lions in the West.

The last of these is unquestionably the most destructive. An adult cougar, according to Dixon (30, 31), destroys about 50 deer annually. He furthermore estimates that the annual kill by these animals in California alone is 30,000 deer, which equals the annual loss due to hunting. By comparison, the bobcat and timber wolf are second-rate killers, though by no means to be ignored. On the Superior National Forest in northern Minnesota, the average kill per wolf is considered to be about 6 deer per year, or an annual loss of around 1,500 deer for the wilderness section of this forest or a deer for each 1½ square mile (*1 Gray Wolf*). Considered in the light of a total population of 11 deer per square mile this loss is not serious. Moreover, the wolf has been reduced so near the vanishing point in all but the more remote sections that its depredations are decidedly limited in occurrence.

The bobcat, though popularly regarded as a predator of great importance, is probably not wholly deserving of this stigma. It is evident from stomach analyses of Vermont bobcats in which remains of deer were found in about 20 per cent of the stomachs that these animals consume deer meat in quantity.[1] But evidence of this nature is doubtless less incriminating than the figures suggest, for carrion may be the principal source of such deer remains. Although it is unquestionably true that the larger cats can bring down even a big healthy buck—and sometimes do—for the most part they prey upon smaller game unless driven by extreme hunger. Even then it seems likely that they confine their attack upon deer largely to animals caught at a distinct disadvantage, such as unprotected fawns and individuals half starved, injured, or trapped by deep snows.

Numerous other animals are known to kill deer on occasion, among them being the coyote, fox, black bear, and golden eagle. None of these is important, except perhaps the coyote, and even the case against that animal is not especially convincing.

Probably more destructive in the aggregate than any of the foregoing animals, unless it be the mountain lion, is the domestic dog. In settled regions this animal is the predator of prime importance, due to its universal presence and the persistence of its attacks. Once a dog acquires the deer-hunting habit, it must be dealt with summarily, for the habit is not otherwise easily discouraged.

Not all mortality of deer is attributable to predators, however, and deaths resulting from accidents, both natural and unnatural, are perhaps more common than one would suppose. This is particularly true in districts having numerous highways and railroads, where automobiles and

[1] Hamilton, W. J., Jr., and Russell P. Hunter. 1939. Fall and winter food habits of Vermont bobcats. *Jour. Wildlife Mangt.* **3**(2):99–103.

trains take a steady, if not a considerable, toll. Where routes of common carriers traverse winter-yarding areas, the danger is greatly increased. Other accidents also occur in nature. Bucks with antlers caught in trees or locked in combat with other males from which they are unable to disengage themselves die of starvation or succumb to predation. Other animals break through ice too thin for their weight and drown or fall on icy surfaces and are unable to regain their feet. Still others break a leg or otherwise suffer injury and eventually fall to their enemies or die of starvation.

TABLE 45. ESTIMATED LOSSES DUE TO HUNTING, PREDATION, AND MISCELLANEOUS CAUSES ON THE NATIONAL FORESTS OF THE UNITED STATES AND ALASKA DURING 1940 (8)

Region	Total deer population	Hunting take		Loss due to predators		Miscellaneous losses		Total all losses	
		Number	Per cent *	Number	Per cent *	Number	Per cent *	Number	Per cent *
1	137,000−	9,800−	7.2	6,600−	4.8	6,300−	4.6	22,700	16.6
2	194,000−	14,000−	7.2	7,600−	3.9	9,900−	5.1	31,500	16.2
3	132,000	7,000	5.3	17,000	12.9				
4	245,000−	43,000−	17.6	18,000−	7.3	11,000−	4.5	72,000	29.4
5	395,000−	28,000−	7.1	14,000−	3.5	14,000−	3.5	56,000	14.2
6	243,000−	21,000−	8.7	35,000−	14.4	20,000−	8.2	76,000	31.3
7	48,000	11,000	23.0	. . . . . .	. . . .	6,000	12.5		
8	36,000−	1,800−	5.0	600−	1.7	1,100−	3.0	3,500	9.7
9	335,000	37,000	11.0						
10	48,000−	3,000−	6.3	6,000−	12.5	1,800−	3.8	10,800	22.6
Totals *	1,298,000	120,600	. .	87,800	. .	64,100	. . . .	272,500	
Average †	185,429	17,228	9.3	12,543	6.7	9,157	5.0	38,928	21.0

* Percentage of total deer population.

† Based on the combined total deer population of only the seven regions reporting complete returns on all types of losses.

Altogether, the loss of deer incurred by predation, starvation, and miscellaneous causes comprises in the aggregate an imposing rate of mortality. The importance of these factors is well illustrated in Table 45, which compares the various classes of deer mortality reported from the various National Forest regions of the nation. The data contained in these comparisons emphasize clearly the fact that the aggregate losses of the type under consideration in this section exceed considerably the legal hunting take.

Loss Due to Hunting. It is a generally accepted principle that the basic growing stock of a deer herd suffers no decrement if the legal hunting take is not permitted to exceed 20 per cent of the total population. Wherever the object of deer management has been to raise the population level, hunting has been so regulated that the annual take was below this standard.

That hunting pressure of this intensity may be permitted without taxing the reproductive capacity of a normal herd is borne out by the data summarized in Table 46. The point to be noted is the continued increase in numbers despite the moderately heavy hunting take. This increase in deer was accomplished, however, where food conditions were satisfactory and losses from other causes were low.

TABLE 46. THE ESTIMATED POPULATION AND HUNTING LOSS OF WHITE-TAILED DEER IN THE HURON NATIONAL FOREST IN MICHIGAN, 1937–1941 *

Year	Estimated total deer population	Legal hunting take	Per cent of total
1937	20,000	3,029	15.1
1938	25,700	3,092	12.0
1939	19,000	2,985	15.7
1940	33,000	5,100	15.4
1941	33,000	6,200	18.8
Average	26,140	4,081	15.6

* Annual wildlife reports of the U S Forest Service, Region 9.

Certain states have adopted regulatory legislation that protects does at all times—the so-called "buck law"—a measure that has had a consequent marked effect upon the rate of population increase. In fact this practice proved so successful in Pennsylvania that strong countermeasures became necessary to avert the threat of overpopulation. To that end for a number of years the shooting of "antlerless" deer has been practiced periodically as a means of drawing off the excess numbers. For example, the kill of nearly 172,000 animals for 1938 in Pennsylvania was roughly equivalent to the normal take of 3 or 4 years (39, 41, 42, 43). In Michigan, where the buck law has been in force for two decades, the typical season's harvest of 40,637 deer in 1937 stands in sharp contrast to the estimated annual increment of 400,000 animals (11). An extra open season of 4 days in Wisconsin in 1943 was added to the regular 4-day deer-hunting season. During the extra hunting period the shooting of antlerless deer was allowed. As a result of these two seasons an estimated 105,000 deer were bagged that year (10).

Further evidence that properly regulated hunting is not detrimental to the productive capacity of a herd is shown by the following record of hunting take in the four New England states having a legal open deer season. These data are noteworthy in that they show a significant increase in annual yields from year to year, an indication that overhunting is not taking place. The annual take in these states, 1920–1938, is shown on page 213.

A comparison of the take in a number of Eastern states generally regarded as fine deer-hunting range is presented in Table 47. In comparing

State	1920	1930	1933	1936	1937	1938
Maine	.		16,083	16,815	19,161	19,363
New Hampshire		1,735	1,845	2,751	3,218	3,363
Vermont	4,498	951	2,039	1,997	2,446	2,433
Massachusetts	1,466	1,562	1,813	2,009	2,567	2,303

these data it should be borne in mind that Wisconsin, with a few exceptions, has had an open season but 1 year in 2, while the other states allow deer hunting every year.

TABLE 47. THE HUNTING TAKE OF WHITE-TAILED DEER IN SEVERAL EASTERN STATES SHOWING THE KILL-AREA RATIO *

State	Year	Square miles of range	Hunting take	Square miles per deer killed
Maine	1940	32,600	22,122	1.47
New Hampshire	1937	7,000	3,218	2.18
New York	1938	18,100	11,500	1.58
Pennsylvania	1937	12,500	39,347 †	0.32
Michigan	1937	34,500	40,637	0.85
Wisconsin ‡	1936	25,000	29,049	0.86

* Data from the annual reports of the fish and game departments of the various states.

† This figure represents bucks only and is reasonably typical of the average hunting season However, during seasons that permit the shooting of both sexes and all ages as a means of removing excess population, the annual take is often several times greater, being nearly 187,000 in 1940 (45).

‡ Open season every second year

Since the true measure of hunting success or lack of it is measured in terms of the average take per hunter, information concerning good deer hunting is deserving of mention. In general it may be stated that hunting conditions are excellent if one hunter in two is successful. The average on good deer range is nearer one in three or four.

Additional data of interest is provided by the records of the Chequamegon National Forest in Wisconsin (69). The hunter-success ratio, *i.e.*, the ratio of legal take to number of hunters, for the four open deer seasons in the period 1934–1938 was 1 to 3.5, 4.5, 8.4, and 4.7, respectively. The average number of hunting days required to kill one legal buck ranged, according to the year, from 12 to 18 days, and the average number of hunting hours per hunter in the field was about 40 hours. Two-thirds to three-quarters of the deer bagged were shot standing, and between three and four shots were required on the average to kill a deer, but the number of shots ran as high as 35! Forty to fifty per cent of the take was bagged between 8 and 10:30 in the morning, and about 30 per cent from noon to 4:30 P.M. During 7 days of deer hunting some 50 per cent of the total kill was registered the first day; in all, 84 per cent of the kill occurred during the first 3 days of the legal open season.

Losses due to crippling and poaching are unquestionably heavier than similar losses among game birds and smaller mammals, for the deer is an elusive target despite its size, as well as a durable one. Not all wounds are inflicted in vital spots or become immediately fatal. Many an injured animal escapes its would-be slayer only to succumb eventually either to its wounds or to its natural enemies. Moreover, considering the prize, the incentive for poaching is great, and losses of this character are considerable even where protection and law enforcement are well organized. The hunting records of the Chequamegon National Forest already referred to suggest the seriousness of losses resulting from crippling and from shooting does and fawns (69). Between 1934 and 1938 the estimated hunting loss for the Chequamegon Forest was 13,848 legal bucks and some 4,000 illegal does and fawns, the illegal take being approximately 30 per cent of the legal take and 23 per cent of the total take. In 1937 for every 100 legal deer removed there were 68 others, legal and illegal, left in the woods dead or seriously crippled. In 1938 the ratio was 100:60. One out of every six hunters reported having witnessed the shooting of illegal deer. This probably represents a normal condition where the buck law is in effect and does not indicate, as might be construed, an extreme condition of lawlessness for this part of Wisconsin.

MANAGEMENT

The rapid increase in deer population during recent years, particularly on the eastern range, has given rise to a number of vexing problems in wildlife management. The most pressing of these in certain localities is the matter of overstocked range, which has come about through a too rapid expansion of deer populations (33, 54, 55). This is primarily a situation correlated with insufficient winter browse. Other problems relate directly to the detrimental effect upon man's welfare of the larger deer herds and their expansion into new range—such effects, for instance, as damage to orchards, agricultural crops, and forest reproduction or the contamination of public water supplies by decaying carcasses of starved animals (64). These and other problems concerned with the development of cover and food supplies and special management techniques will be discussed in the following pages.

Census Methods. Until recently there has been no accurate means of estimating deer populations (51). The usual practice, based mainly on the interpretation of signs such as tracks, droppings, and degree of browsing, gave decidedly unreliable results. For example, Michigan's initial estimates determined by these and similar empirical methods were in error by approximately 100 per cent (11). Other states have made the same type of error in relation to deer populations. It is also highly probable, by and large, that many other early estimates were equally inaccurate. The use

of the drive-census method has helped to correct many of the prevailing low estimates of deer numbers (*2 g.r.*).

Basically, the drive-census method is a sampling technique, or partial-estimate system, by which the population on any given unit of range is computed by proportions from 100 per cent counts on selected sample plots of known area. Populations of deer in the sample areas are determined by carefully executed deer drives. The degree of accuracy attained depends upon the care with which the drives are planned and conducted and the size, number, distribution, and normality of the samples. Sample units of about 1 square mile in area are recommended. In view of the obvious physical difficulties involved, the combined area of all samples rarely exceeds 1 per cent of the total. A greater degree of sampling is highly desirable, but generally not feasible.

Sample units are selected and prepared in advance of the drive. If the census is to be repeated year after year, each sample unit becomes part of an established system of sample areas, having boundary lines, interior guide lines, and other features permanently marked, usually by paint and stakes. The boundaries must be sufficiently free of brush and other obstacles to permit unobstructed vision for distances of at least 100 feet and preferably 300 to 500 feet. This means that considerable preliminary clearing is usually necessary unless sample units are selected with an eye to placing boundaries along roads, trails, stream channels, and similar breaks in the vegetation. Observation stations are established around the boundary at convenient points so that each station commands a clear view to the two stations immediately adjacent. The locating and marking of interior guide lines to assist the "drivers" are desirable but not essential. Additional lines are commonly established at intervals of ¼ mile and traverse the sample unit from one boundary to the other, at least in the direction of the drive and sometimes at right angles as well, thus permitting realignment in two directions.

Details of the drive are simple. "Counters" are stationed along the boundary on three sides of the sample, each at one of the previously established observation points. The drivers line up along the fourth side and at a prearranged signal proceed abreast across the sample, driving the deer within the area ahead of them and eventually outside it. Deer that cross the boundary are recorded by the posted counters, and those which cut back over the driving line are tallied by the drivers. By prearrangement, each counter and driver is responsible only for a certain sector of the line. For example, the drivers may be instructed to report deer crossing on their right but not their left. The counters always face the station ahead and ignore any animals crossing to their rear.

The interval between drivers varies from 50 to 100 feet, depending upon visibility. The direction of travel across the sample is indicated by guide

lines if these have been laid out previously; otherwise, key men along the drive line determine the course by compass. Where guide lines have been established at right angles to the direction of the drive, the advancing drivers stop as each line is reached until all participants are once more in position, then proceed again on signal.

The autumn season between the time of leaf fall and the beginning of local migration to winter yards is the best time for conducting a drive census, visibility being greater then than earlier and the recognition of the sexes easier. Experience has shown, however, that efforts to obtain an accurate tally by sexes and age classes are generally unsuccessful.

The drive census is undoubtedly the most accurate of the methods yet devised, but also the most expensive, requiring the lavish expenditure of both time and labor. Between 100 and 150 men are needed to ensure the attainment of a satisfactory standard of accuracy, and two drives constitute a day's work. Unless the bulk of such labor is contributed free of charge, this method is too costly for intensive application or frequent repetition. Morse (59) has devised a way to reduce the number of men needed for the method just described, by conducting the drive after a fall of fresh snow and reducing the "counters" to three crews of two men each. These crews first obliterate any tracks on three sides of the sample area, then count the tracks that crossed the boundaries after each drive.

A more recent and less costly method than the preceding technique, known as the *track-and-bed-count census*, has been used with considerable success under favorable circumstances (*7 g.r.*). The presence of a tracking snow is a prerequisite. As a means of estimating populations in winter yards this method has merit. It consists of two separate procedures: (1) a count or estimate of the fresh (not over 24 hours old) deer beds within the census unit and (2) determination of the average number of beds occupied by an individual deer during a single day. With these facts at hand an estimate of the total population within the census unit is easily computed.

To accomplish the first of these two objectives the census unit is traversed at intervals along a series of parallel 1-chain strips on which the fresh beds are tallied. If reasonably accurate results are to be obtained, the interval between strips should not be greater than 10 chains. At the maximum interval the area thus sampled is approximately 10 per cent of the total. Precise determination of this relationship requires prior knowledge concerning the area of both sample and census unit. To secure an accurate tally of deer beds, the sample strips are examined on two successive days. The second day's tally minus that of the first day gives the number of new beds.

The average number of beds that an individual deer occupies in the course of 24 hours is determined through observation. This is accom-

plished by following a fresh set of tracks until the deer is jumped, noting the number of beds along the way and repeating the procedure with the same animal for several days running, picking up the track each morning at the flushing point of the preceding day. However, if the deer is bedded down at the time of flushing, it is likely to bed down again somewhat later, thus adding an extra bed to that day's total. The error introduced by this contingency may be considerable. This abnormality can be overcome for the most part if the procedure just described is modified to the extent of following the deer less closely after the initial contact, allowing an interval of 3 or 4 days to elapse before jumping it again. Following tracks under such circumstances obviously requires nearly ideal conditions and a skillful technician. If applied to a sufficient number of deer, this technique provides a satisfactory mass of data from which to calculate the required average. Once this average has been determined within reasonable limits of error, it can be applied without further modification to future census operations in the same general vicinity. Experience indicates that deer bed down about twice during a 24-hour period.

Population on the sample is computed by dividing the tally of fresh beds by the average number occupied by a single deer during a 24-hour period. Population for the census unit is then derived from the calculated density on the sample.

This method of census has the advantage of being inexpensive and requiring no more than two men for its initial successful application and only one man after the sample strips have been located and their lengths measured. It has particular merit if the system of strips is permanently established for repeated use year after year. One man can then carry out all necessary field operations.

A one-man deer-census technique known as the *cruising method* has been suggested by Erickson (32) under Minnesota conditions and tried in Oklahoma with success by Krefting and Fletcher (53). This method is similar to the King-census method described in the chapter on *Ruffed Grouse*. In the cruising-census method cruise lines are run at ¼- or preferably ½-mile intervals on not less than 4-square mile samples and cruised by a skilled technician much as a hunter would stalk a deer. Lines are walked during early morning and in the twilight of the evening. Weather conditions considered most favorable are cloudy days with little or no wind and when the ground is moist. Items needed for calculation of the population are the following:

Z = number of deer flushed
X = lineal distance of census lines
Y = flushing distance
A = area of census sample

The formula for calculating the deer population is

$$P \text{ (population)} = \frac{AZ}{X2Y}$$

This method has the advantage of being economical as to man power needed and reasonably accurate within limits. It appears to work better under conditions of open cover, when the foliage is less dense and when insects are at a minimum.

Census determinations by *monthly counts of pellet groups* are described by Bennett, English, and McCain (13). Like the preceding method this is an economical procedure, but its accuracy is open to question. It is predicated on the premise that the periodic accumulation of deer droppings bears a direct and proportional relationship to population density. If this basic assumption is accepted, it is possible by careful study in localities of known deer concentrations to determine the quantitative nature of this relationship, and the standards thus established can then be applied to similar habitats elsewhere as an *approximate* measure of comparative populations.

The authors referred to above based their determinations upon sample plots of 1/10 acre or sample strips measuring 11 by 1,000 or 2,000 feet and an accumulation period of 1 month. At the end of every period the pellet groups on each plot were carefully tallied and then removed in order to avoid duplication at the next count. These periodic tallies were continued throughout the spring and summer seasons, these being the only periods of year to which this method is well suited. From the data thus obtained several interesting comparisons were derived which are summarized below:

Average monthly accumulation of pellet groups per acre	Acres per deer *		Forest cover
	1937	1938	
12	60	72	Chestnut oak, 40–100 years old
19	46	69	Pole stand of hardwoods
26	14	18	Scrub oak = pitch pine barrens
54	6	14	Slash

* December populations; summer populations were probably larger.

It must be remembered that these values are merely illustrative and that determinations of this nature necessarily lose their significance outside the general locality of their origin. Wherever this method is adopted, local standards must be devised, and even then particular attention must be given to the influence of cover and other habitat variables.

Census studies based on *track counts* have been tried with considerable success in Colorado during the period of spring migration (76). In this

particular method, tracks of the migrating deer were tallied each morning along a little-used road that cut across the route of migration. After each enumeration all tracks were carefully obliterated by dragging the road with pine tops chained to a truck. Tallies were taken on 22 miles of road over a period of 5 weeks. Twenty-two men were employed to make the daily counts. During this period approximately 28,000 tracks were enumerated.

In North Dakota Saugstad (70) has developed the *census by airplane*. A state-wide big-game survey conducted in this manner gave outstanding results. The plane from which game was tallied traveled along a prearranged course at a height of approximately 375 feet. Lines of sight marked off on the wing struts permitted each of the two enumerators, one on either side of the plane, to observe a sample strip of fixed width on the ground. Tallies recorded on these strips formed the basis of census calculations. The standard sample gave a 25 per cent estimate; but since larger samples were employed in certain sections, the average coverage for the state was 34 per cent. The survey covered 11,000 square miles of range at an average cost of 12 cents per square mile.

This method has its limitations, however. It is well adapted to regions having flat terrain and deciduous forests primarily, but under all other conditions its usefulness is definitely restricted. Winter is the only season of the year when it can be employed successfully. Eventually, difficulties arising from unevenness of land surface may be overcome by improved technique, but it is doubtful if a satisfactory solution of the visual problems arising from the masking effect of coniferous cover can ever be attained. However, perfection and use of the helicopter may overcome many of the difficulties encountered in using the conventional type of airplane in making game censuses.

Finally, Hickel and Swift (47) found that the number of pairs of mule deer antlers picked up around feeding stations tallied quite closely with the number of bucks present.

Food and Cover Development. Because the deer is a forest animal, its management with respect to food and cover development is intimately associated with the utilization of land also producing wood crops. It is only natural, therefore, that the application of silvicultural practices to forest stands should be the principal means of manipulating this environment to the advantage or disadvantage of a deer herd (61). In fact, the application of other more intensive methods of habitat improvement is rarely economically feasible, considering the extent and nature of the areas requiring attention. Except on winter range, which is both more crucial to the survival of the herd and more susceptible of specialized treatment, improvement projects involving detailed and expensive techniques are neither necessary nor feasible in most cases. In other words, stating the case plainly, there is little that can be accomplished to augment range

carrying capacity beyond the liberal application of broad extensive measures such as forest cuttings and the limited use of more intensive practices in winter yarding areas. If these measures are not sufficient to avoid an overpopulated condition, the only solution is to reduce the herd by heavier hunting.

Fortunately, proper forest management is also good deer management, and a program of frequent cuttings, systematically applied, is the best guarantee of a satisfactory and reasonably stable habitat. While it is true that the creation of extensive areas of young second-growth hardwoods by large-scale cutting operations in the past has been primarily responsible for the rapid increment of the eastern deer herds, it is equally true that a less equitable distribution of age classes is also to be desired from the viewpoint of maintaining a relatively constant population. Otherwise, the range carrying capacity is subject to periodic fluctuations, being greatest when young stands are numerous and least when these mature. Unfortunately, there is no fundamental cure for this situation, since for obvious reasons the maintenance of forest stands in a permanently youthful condition is manifestly impracticable. The best compromise, therefore, is the all-aged forest with its age classes well distributed in a groupwise manner over an extensive area.

Turning now to more specific forms of treatment, the following practices are recommended. Some are more generally applicable than others, and in the main they apply more particularly to the eastern range. Management in the West is still somewhat nebulous.

1. *The gradual conversion of even-aged forests to uneven-aged forests.* The desirable features of this recommendation have already been pointed out. Although a project of this magnitude is a long-time proposition requiring many years for completion, its gradual accomplishment can be effected by proper forest regulation. Since this objective is also the goal of sustained-yield forest management, its attainment is doubly desirable (61).

2. *The maintenance of existing hardwood cover and the conversion of large unbroken blocks of conifers to stands of mixed composition in which the hardwood component would be well represented.* The degree to which this aim can be achieved is governed primarily by practical considerations. In regions where the principal timber species are softwoods, the encouragement of hardwoods must be pursued on a more limited scale than elsewhere. This is particularly true in the West and to a lesser extent eastward in the Northern states and Canada. However, even where hardwood forms the dominant vegetation and can be maintained as such, the complete elimination of conifers is far from desirable. On winter range in particular, coniferous species play an important role, their evergreen crowns affording much better protection against snow and wind than the leafless crowns of the hardwoods. For this reason their presence, at least in small numbers,

should be fostered, while a greater representation, even if in relatively pure stands, is not objectionable provided more suitable cover types predominate.

3. *The application of intermediate cuttings such as thinnings and improvement cuttings to immature stands beyond the sapling stage.* As even-aged stands advance from the seedling stage into middle age, the volume of available browse becomes progressively less abundant, at times decreasing even to the point of scarcity in stands of abnormal density. Cutting is the only remedy for a situation of this kind. Since such stands are not yet ripe for harvest, intermediate cuttings are called for. Their principal effect in augmenting the dwindling food supply is to stimulate the growth of browse plants on the forest floor. Following partial cuttings of this nature, sprouts usually spring up in profusion from the cut stumps of hardwoods, and plants of seedling origin commonly become established wherever the overhead canopy is opened sufficiently to permit the entry of light onto the forest floor. Heavy improvement cuttings are particularly beneficial in this respect, even in coniferous stands. In stands that require thinning, low thinnings are more productive of sprout growth; crown thinnings provide greater stimulation to seedling growth and production of mast. Conifers, therefore, should be handled by the latter procedure; hardwoods may be handled by either method, although thinning from below is perhaps preferable, at least in the early stages when stumps are small and numerous. Later, crown thinnings are probably of equal value.

Where more intensive improvement measures are practicable, the cutting back of shrubs will significantly increase the volume of sprout growth. This practice is comparable in effect to a low thinning and is, in fact, merely an extension of this principle. It has been employed successfully by Krefting (52) in Minnesota. But because of the high costs involved, its application should be restricted to overbrowsed winter areas. Improvement of chaparral deer range in California can be brought about by cutting or burning back this type of cover in carefully selected blocks every 2 or 3 years (66).

4. *The harvesting of mature forest growth by clear cutting in small blocks or by the selection principle* (preferably group selection, keeping the groups as large as silvicultural considerations permit). The larger openings are particularly desirable when the forest cover contains a high representation of shade-tolerant conifers; otherwise, the volume of hardwood browse is likely to be inadequate. On the other hand, in selection stands composed largely of hardwoods, it probably matters little whether the forest is managed by group or single tree cuttings. With either of these two methods of selection cutting browse plants are generally abundant.

5. *Release cuttings around fruit-bearing vines and shrubs and the pruning of wild apple trees.* These measures are designed to prevent suppression and

encourage fruit production. Plants worthy of such treatment include wild grape, hawthorn, and wild apple (4 *Wildlife Management in the Forest*).

6. *Development of connecting lanes between adjacent deer yards.* For some as yet unexplained reason, a deer herd in a given locality tends to frequent certain yarding areas year after year, even though these may be heavily overbrowsed, while equally suitable areas in the same vicinity receive relatively little use or none at all. Deer have been known to starve in droves while abundant food supplies close at hand go begging. Once yarded for the winter, the animals seem loath to venture forth into new territory if it requires traversing unprotected slopes or similarly exposed situations. The development of connecting lanes between yards corrects this difficulty to some extent. These lanes may be of two types: strips of planted conifers, which provide shelter, or clear-cut aisles, which provide feed in the form of sprouts. Lanes of this sort more or less "lead" the deer from one yard to another and to some extent partially overcome their disinclination to leave otherwise (4).

7. *The development of winter food supplies by planting.* This practice has been employed on a very limited scale to date, but it may prove useful in the future. Little-used yarding areas can be improved substantially in this manner through the planting of northern white cedar. Once trees of this species have become well established, they provide nutriment of a high order. It must be borne in mind, however, that planting cannot be accomplished successfully in yards subject to heavy annual use, for here the plants are quickly browsed back and killed. Planting is of value principally in the improvement of less frequently occupied yards, which will come into use later as the deer herd grows in size or changes its overwintering habits, as it commonly does in the course of time.

8. *Emergency feeding during winter.* In times of acute food shortage, resort to this practice may or may not provide the means of averting wholesale starvation (18). However, it must be regarded primarily as an emergency operation that has no permanent place in the management of a well-regulated deer herd. If the character of winter range is such that artificial feeding becomes necessary winter after winter, an overpopulated condition is clearly indicated and corrective measures should be adopted at once.

Alfalfa has been more widely used as an emergency winter feed than any other material, but even this food material is expensive and must be provided in large quantity, since the stems and coarser parts are not readily consumed. Other types of hay, such as timothy, possess insufficient nourishment to sustain life if dependence is placed solely upon such materials, and their use is not recommended. Perhaps the most satisfactory type of emergency ration is the concentrated food cake known as New York deer cake. This consists of a mixture of various food materials prepared in

small compact units suitable for storage and of a size sufficiently small to facilitate ease of transportation. Distributed about the winter range, these cakes provide an excellent source of nourishment (57). This cake concentrate contains 45 parts of cane molasses and 55 parts of ground soybeans. Packed in tinned units of 25 pounds each, the cake keeps well and is easily transported. Placed in the field for use, it is wired to a tree trunk or old stump. When the food is needed, the can is removed and the contents covered over with boughs of favored browse plants to attract the deer.

Another emergency measure to increase the deer food supply is the felling of browse trees, thus making available the materials in the tops that normally are beyond reach when the trees are standing. This is a particularly efficacious method when applied to northern white cedar.

Predator Control. The control of predators as a general management policy is of doubtful merit. Wherever deer are abundant, overpopulation rather than the menace of predation is the chief threat to the survival of a herd. Under this condition the systematic extermination of all natural enemies merely adds to the problem. Where the population density is well below the carrying capacity of the range and a larger herd is desired, predatory control is then justified. Dogs, mountain lions, coyotes, bobcats, and wolves are the only carnivores sufficiently destructive to warrant treatment.

Miscellaneous Management Procedures. *Refuges.* As a means of enlarging the deer herd on a sparsely populated range or of introducing deer to virgin territory, the establishment of refuges has given splendid results. The areas thus reserved serve both as "reservoirs" of new stock to populate adjacent lands and as "safety islands" where harassed animals can seek sanctuary during the hunting season. For instance, Swift (73) reported the density of deer populations within Wisconsin refuges immediately following an open season as being about twice that outside where hunting was being permitted. Pennsylvania, Michigan, and New Mexico are outstanding examples of states where refuge systems have been in long and successful use. The fact that this practice is sometimes almost too successful seems to be its principal criticism, for an overpopulated condition of the range frequently develops if the refuge areas are maintained longer than is necessary. Once these sanctuaries have been established, their discontinuance, however well justified, is generally opposed by strong public sentiment (21, 22).

The size, number, and other requirements of refuges needed to meet a particular situation are variable factors. When the population is sparse, more refuges are required than later when the herd has increased. Size depends somewhat upon the number of refuges and partly upon their function. Refuges meant to serve primarily as sanctuaries during the hunting season need be no larger than a few hundred acres. On the other hand,

areas set aside as a reservoir for new stock ought preferably to contain several thousand acres. Standards set by the U.S. Forest Service (*2 g.r.*) recommend that the size of a refuge should approximate the unit range of the species. Four to sixteen sections is considered satisfactory. The distance between refuges "should be no less than twice the annual mobility," which for the eastern range is generally 5 to 10 miles. Each refuge site, especially the larger units, should be selected with an eye to satisfying habitat requirements at all seasons and "especially should remedy the limiting factors in the surrounding range."

When a refuge system is first established, special protective measures are frequently necessary, particularly in districts where deer are being introduced, for here the likelihood of poaching is great. The permanent services of a refuge keeper and temporary assistance in the form of patrolmen are commonly of prime necessity. In some of the southern National Forests, a nucleus of breeding stock is confined in fenced enclosures of about 100 acres near the center of the refuge. Each year a new crop of yearlings is released onto the unfenced portion of the refuge. This ensures maximum protection for the basic growing stock on each refuge.

Control of Deer Population. Leopold (54) states that deer and elk do not disperse after they have depleted their food supply and that the dispersal function was formerly accomplished by the larger predators of deer. Under conditions of an overpopulated deer range it would seem to be a wise policy to allow the predators of deer to remain, even though some domestic livestock is lost through their presence.

When damage to range vegetation occurs because of too many deer, and a loss of domestic livestock occurs because of large predators, the damage to the range usually develops into the more serious of the two adverse conditions. Under such circumstances it would seem wise for stockmen not to advocate predator bounties and to insist that the deer herd can be reduced by some other means in addition to natural control.

The control of deer populations, in the sense of maintaining them within the bounds of a range carrying capacity, is essentially a problem of controlled hunting. As stated in the foregoing section, attempts to accommodate a rapidly increasing deer herd by cultural practices designed to raise the carrying capacity rarely prove feasible. The only sound solution in this case is to reduce the number of animals using a given unit of range. To date, hunting has proved the most satisfactory means to that end. The trapping and transportation of animals to less densely populated sections have been practiced on a limited scale, but because of the expense and physical difficulties involved it is not likely to gain favor as a corrective measure. As a method of establishing colonies in a new range this practice is excellent, but as a cure for overpopulation its limitations are obvious.

Efforts to increase the hunting take are not always accomplished with

ease, however. In most states restrictions that regulate hunting are established by law, and any attempt to alter these regulations in a way that permits a greater kill often encounters stubborn opposition. Although the general public is quick to resent the suggested shooting of more animals, especially does and fawns, on the grounds that such action is inhumane, it is slow to grasp the realization that death by the gun is more merciful than death by slow starvation and disease. Only by a long-time program of education can this public attitude be overcome (45).

Control by hunting is effected in numerous ways: by increasing the length or frequency of the open season, by shooting antlerless deer as well as bucks, or by more careful distribution of the hunters, *i.e.*, steering them into areas of heavy concentration. The shooting of antlerless deer has been practiced periodically in Pennsylvania for at least two decades and in particular since 1928. In the years of unusually heavy take the harvest has been three or four times that of a normal season when only males are killed. Effecting a more equitable distribution of hunters by directing them to districts where the population is dense has been tried with considerable success in National Forests in Michigan and North Carolina. In Michigan this has been accomplished mainly by officials located at deer-checking stations placed at intervals along the main roads leading into and through the forests. But perhaps the best example is the Pisgah National Forest in North Carolina, where supervision has reached a degree of control beyond anything attained elsewhere on an area of comparable size. First, the number of animals to be harvested and the localities where they shall be shot are determined in advance of the hunting season. Later, statements printed in newspapers and otherwise distributed announce the hunting season and dates when applications for hunting certificates will be accepted. Hunters then apply for their certificates, and those to receive them are chosen by lot. Each applicant thus selected is notified of his choice and the days when he may hunt. Each is allowed one deer, and for the privilege of hunting he is charged a nominal fee, which covers administrative costs. The hunters report each morning at a designated point of entry, travel to and from their hunting grounds in official trucks, hunt only on range prescribed by a forest ranger, and check out when they leave. Each hunter is permitted a 3-day period in which to bag his deer.

Wisconsin reduced its surplus deer in 1943 by adding a 4-day season for antlerless deer following a closed period after the regular hunting season (10).

Redistribution of Deer. Transporting deer from one locality to another is resorted to mainly as a means of establishing a nucleus of breeding stock on hitherto unoccupied range. As an example, deer trapped in Minnesota were the source, in part at least, of the present herd in Missouri, and similar transfer operations have been undertaken from Michigan to parts

of the South and locally in Arkansas (75). If such "plantings" are to proceed satisfactorily, each pioneer colony should be established in a refuge and adequately protected. Otherwise, the effort and money expended can hardly be justified.

Two types of *trapping devices* are in general use, the box type and the corral type. Of the former, the Stephenson and Pisgah traps are the best known. Both are highly satisfactory. The Stephenson trap (4) is a rectangular wooden structure, 12 feet long, 4 feet wide, and 4 feet high. The sides and top are of solid construction, and the two ends are built in the form of sliding panels which serve as trap doors. When the trap is set for operation, these panels are raised and held in position by overhead ropes, which connect with a trigger mechanism inside. Enticed there by bait, the deer enters the trap and at length trips the trigger that releases the doors. If the trap is made as nearly lightproof as conditions permit, injury to a captive animal is very largely avoided, since its efforts to escape are reduced to a minimum by this precaution. Interior surfaces of the trap should, of course, be free of protruding nails and other obstructions; the trigger should be so located that when trapped the prospective victim is well inside the trap. Otherwise it is likely to escape or suffer serious injury from the falling doors, which are often heavily weighted.

The Pisgah trap (67) differs from the preceding mainly in that it employs a screened approach which connects directly to an enclosed box of somewhat different construction from the Stephenson trap but similar in principle. There are three trap doors: one at either end of the box, operated simultaneously by a trigger in the box, and a third at the outside entrance to the screened approach, tripped from inside the approach by a trigger operating independently of the trigger controlling the door of the box. The deer is first trapped in the approachway and, after futile efforts to escape by the way it entered, dashes for the far end of the box which is still open, releasing the second set of doors en route. The screened approach is simply a wooden frame structure measuring approximately 7 feet long, 4 feet high, and 4 feet wide, covered with strong wire poultry netting of 1-inch mesh. The enclosed box, having an over-all length of about 10 feet, is of solid wood construction and tapers in size from its maximum dimensions at the point of juncture with the approachway to about 3 feet high by 2½ feet wide at the outlet. This feature facilitates the transfer of the trapped animals to shipping crates.

The corral trap consists of a fenced enclosure about 40 feet in diameter, which is entered through one or more trap doors, tripped by hand. The fence must be at least 8 feet high and may be constructed of small-meshed wire or lumber. The latter material is less likely to cause injury once the deer have been caught, but it is more apt to arouse their suspicion before they enter the corral. In operation the trap is first baited and the doors

left open for a considerable period until the deer lose all fear of the enclosure and enter and leave it freely. Then some day when sufficient animals are assembled inside, the doors are dropped. Transfer to shipping crates is accomplished by driving the animals into lightproof tunnels similar in principle to the Pisgah trap just described.

Whatever kind of trap is used, it must be baited. A variety of materials have been used with success, among them being browse plants (especially northern white cedar), alfalfa hay, apples, corn, garden crops such as cabbage, and even salted peanuts. Numerous designs of triggers for tripping the doors are available and need no description. The mechanism itself is not usually baited but more often depends for release upon direct contact with the deer as it passes by or moves about in search of food materials scattered on the floor. A wire of small gauge or stout cord stretched across the trap near the ground is a commonly used method of effecting contact.

Winter appears to be the only season when trapping can be carried out successfully on a large scale. At other seasons the herd is so scattered that frequent relocation of the trap becomes necessary, which is decidedly impractical considering its weight and bulk. Moreover, it is highly doubtful if even the most tempting of baits would attract deer into the trap at a time when palatable forage outside is abundant. Salt might succeed in this respect, but as far as known it has not been tried.

Shipping crates, like the box trap, are built of lumber and so constructed as to exclude practically all light when the doors are closed. The usual measurements are about 4 to 5 feet long, 3 to 4 feet high, and 18 to 20 inches wide. Crates for fawns should be of the same width but shorter in length and height. Each end opens by a sliding panel door. On better built crates a portion of the top or sides near the caged animal's head may be removed for purposes of inspection or tagging. Transfer of the deer from the trap to the crate is accomplished by forcing the animal snugly against the outlet of the trap; then the outlet door is raised. Most deer enter the crate of their own volition, especially if some light shows at the far end, but a few sometimes require varying degrees of persuasion. Animals may be left in the crates for 36 hours without danger, but preferably not longer. They should be released with considerable care in natural and quiet surroundings. Undue noise and activity must be avoided; otherwise serious injury and even death may result.

The Michigan Department of Conservation has transported deer loose in the back of stake-body trucks (58). A tarpaulin over the top and sides kept out most of the bright light, and hay placed on the floor permitted the animals to lie down in comfort. The deer were loaded through a small door in the tail gate. Both fawns and adults have been shipped successfully in this manner.

Tagging deer for future identification is common practice in several states. Aluminum ear markers [1] of the kind used on sheep and cattle have proved very satisfactory. The tag is simply a narrow strip of aluminum, pointed at one end and bent double in the middle. This is slipped over the ear and fastened in place by a special pincers-type applicator designed specifically for the purpose. If the animals to be tagged are adults, they must be closely confined during the actual tagging operation. For this purpose a shipping crate or special tagging box of similar design is excellent. An opening in the crate or box permits easy access to the deer's head. A blindfold is sometimes useful for the more obstreperous individuals.

Control of Deer Damage. One of the most vexing aspects of deer management is the problem of controlling damage to agricultural crops, orchards, forest reproduction, and similar property. Wherever deer concentrations are dense, damage of this nature is likely to occur. It cannot be denied that destruction by deer frequently attains acute proportions; likewise such damage cannot be easily averted. Despite the expenditure of large sums devoted to the study of this problem, it is yet to be solved. With deer herds increasing rapidly in many sections of the country it is likely to cause even greater annoyance in the future.

Attempted control measures have been numerous. In certain states the right to shoot the offending animals, in season or out, has been established by law. In such states the permission of conservation officials may or may not be required. However, in all cases proper precautions are invoked to prevent abuse of the privilege; for otherwise, poaching in the guise of property rights might well become commonplace. Some states provide for the examination and payment of deer-damage claims.

Noisemakers, flash guns, malodorous repellent compounds, and similar devices designed to frighten the miscreants away are of doubtful value. Their influence is temporary at best, for after several encounters the deer gradually overcome their timidity and soon cease to be alarmed. Deer-proof fences, though affording complete protection, are so expensive to install that the value of property to be protected rarely warrants the monetary outlay required. The electrified fence, now coming into wide use as a means of confining cattle, gives promise of being the best safeguard that a moderate investment can buy. Experiments in New Jersey (56) and Pennsylvania (41) indicate that a fence of this type properly installed is 75 to 90 per cent effective. The more successful installations have been multiple-wire assemblies, utilizing two, three, or four strands, with the topmost wire about 3 to 4 feet and the lowest wire 10 to 15 inches above the ground. Where three or four wires are employed, a more efficient electric circuit is assured if at least one strand is grounded; otherwise, if the surface soil

[1] Tags of the type described and the applicator for attaching them are manufactured by the William Cooper Nephews, Inc., Chicago, Ill.

is especially dry, the circuit may be weaker than desirable. Barbed wire is preferred to smooth wire.

Buffer food strips, if large enough and properly placed, tend to reduce damage to other crops but will not eliminate it. This method has been employed with fair success in New Jersey. Strips of rye and lespedeza, averaging about 4 acres each, were established near principal routes of deer travel in wooded areas. The seed was planted in early fall, and the resulting growth provided forage until early spring.

Damage to forest reproduction is less subject to control by direct methods and must be held in check chiefly through careful regulation of deer-population density. When concentrations are such that serious over-browsing follows as a consequence, the only corrective is a reduction in the number of deer. While damage of this origin can never be eliminated entirely as long as deer are present, the injury caused by a properly regulated herd is rarely sufficient to prevent the establishment of well-stocked, high-quality stands. European foresters regard one deer to 40 acres as a safe stocking. In short, a limited amount of damage must be anticipated if the plan of management embraces the production of both wood crops and a deer herd, but it need not be serious.

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CHAPTER X

PRAIRIE CHICKENS, SHARPTAILS, AND SAGE GROUSE

Tympanuchus spp., *Pedioecetes phasianellus* spp.,
Centrocerus urophasianus (Bonaparte)

GEOGRAPHICAL DISTRIBUTION

Prairie chickens, sharptails, and the sage grouse are all members of the grouse family *Tetraonidae.* Among the game animals being considered in this book, these grouse occupy a rather unique position. Unlike the others they are typically inhabitants of neither true forest nor farm lands. Their preferred habitat is wild grassland and brushy types such as forest reproduction, shrubby thickets, and sagebrush. Although certain species occur mainly in forested territory, the forest is not their characteristic environment. Others are confined chiefly to prairie regions where agriculture has been long established, but here farm land is less preferred by them than the undisturbed prairie close by. Logically, a discussion devoted to these birds should appear in a separate section wholly apart from either farm game or forest game; but because this would be the only chapter so treated, it has been placed under *Forest Game* for convenience. The reader is cautioned to bear this fact in mind as he studies the material that follows.

The prairie chickens are represented by one species and two subspecies. The greater prairie chicken, *Tympanuchus cupido americanus* (Reichenback), is found in the northern prairie from southern Alberta and Manitoba, Wisconsin, Missouri, Nebraska, and the lower peninsula of Michigan. It is by far the most common and best known of this group. The lesser prairie chicken, *T. pallidicinctus* (Ridgway), a smaller bird than the greater prairie, occurs in western Oklahoma, southwestern Kansas, the Texas panhandle, and adjacent New Mexico. Attwater's prairie chicken, *T. c. attwateri* (Bendire), is confined to a narrow coastal strip of prairie near the Texas-Louisiana state line. Its numbers have been sorely depleted, and unless efforts are made to save it, it may become extinct.

Formerly, prairie chickens occupied a more extensive range than at present, especially the greater prairie chicken, which originally occurred as far east as Pennsylvania and in the South to Texas. The ranges of the other two representatives, though greater than today, were never large. Settlement and the development of agriculture have not treated these birds kindly. The Attwater's and lesser chickens have found survival par-

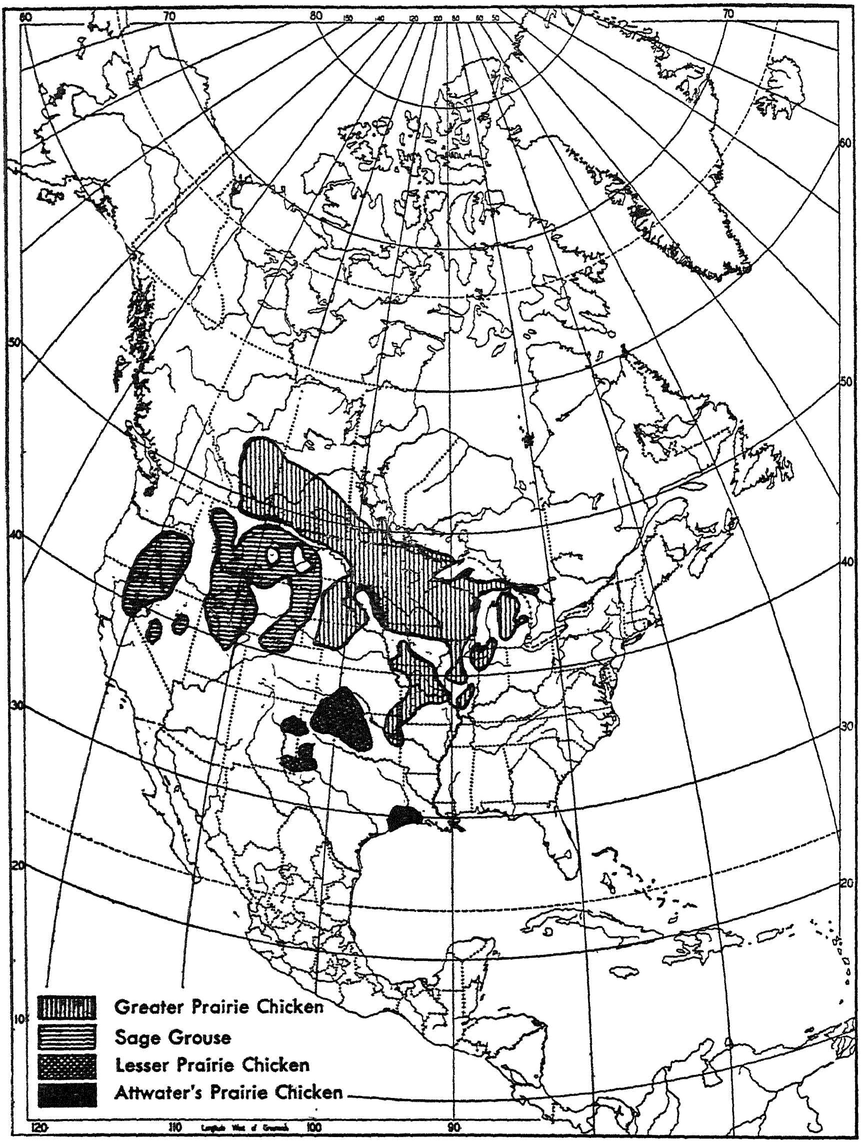

FIG. 10·1. Ranges of greater, lesser, and Attwater's prairie chickens and sage grouse. (*By Robert C. McClanahan,* 1940, *and C. H. D. Clarke, Toronto, Canada,* 1947.)

ticularly difficult. But the case of the greater prairie chicken has been somewhat different. As civilization encroached upon the original range of this species, it migrated to new territory farther north, where a less intensive agriculture has allowed it to survive. Today, the range of these birds lies

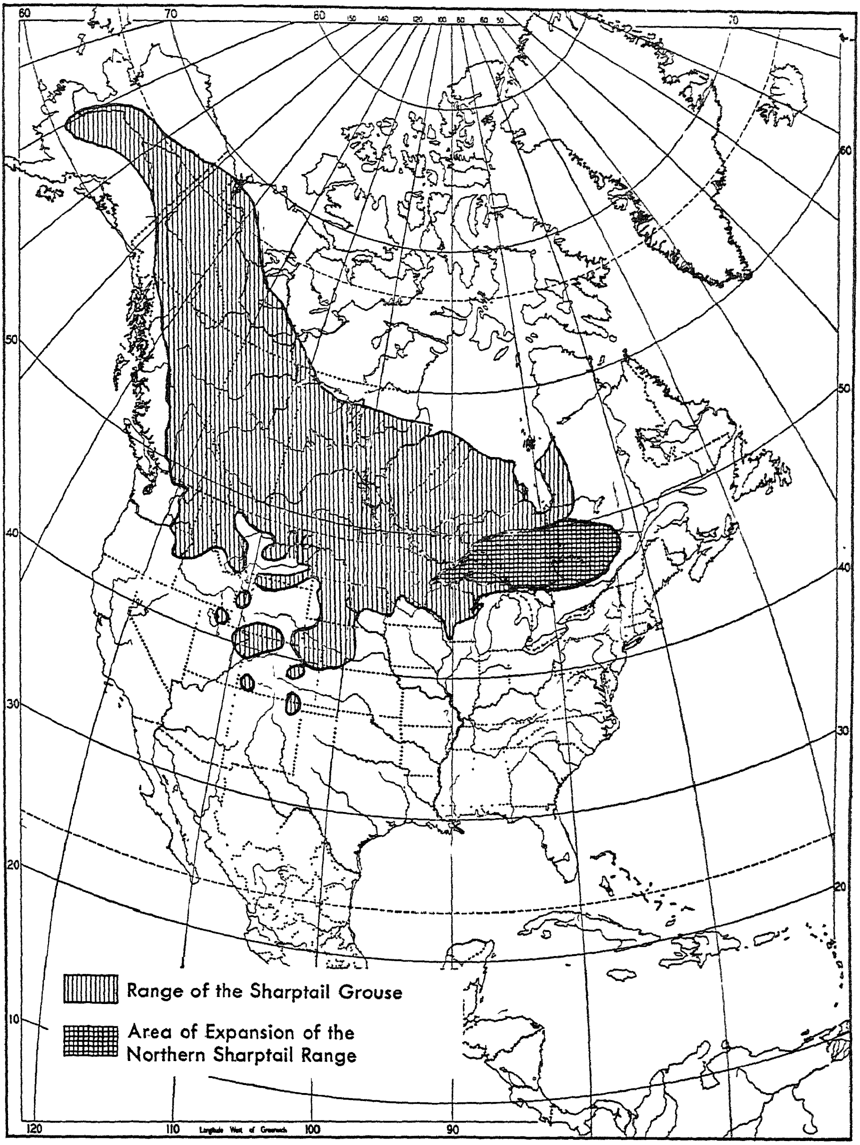

Fig. 10 · 2. Range of the sharptailed grouse. (*U.S. range by Robert McClanahan*, 1940. *Canadian range by C. H. D. Clarke, Toronto, Canada*, 1941.)

at least 50 per cent outside the territory formerly inhabited, mostly to the north and west.

At one time there were four species of prairie chickens, the fourth being the heath hen, *T. c. cupido* (Linnaeus), which, though formerly abundant

along the Atlantic seaboard from southern Maine to Virginia, is now extinct. Despite concerted efforts initiated during the close of the nineteenth century to save it, the heath hen was unable to withstand the pressure of its changing environment. By 1850 this bird had all but disappeared from the mainland, and though managing to survive for a considerable period on certain coastal islands in southern New England it eventually disappeared entirely. The last known representative of the race succumbed in 1931 on Martha's Vineyard Island off the coast of Massachusetts (3).

The sharptails, known also as sharp-tailed grouse, are represented by three subspecies. The prairie sharptail, *Pedioecetes phasianellus campestris* (Ridgway), occurs in western Nebraska, South Dakota, and northward through Wisconsin, Minnesota, North Dakota, and Montana to the southern parts of adjacent provinces in Canada. The Columbian sharptail, *P. p. columbianus* (Ord), is found in the northern portion of the Great Basin from British Columbia to southern Idaho and locally as far south as New Mexico. The northern sharptail, *P. p. phasianellus* (Linnaeus), occupies a range more or less coextensive with the boreal forests of Canada from western Quebec to the interior of Alaska. Southward the range merges into and in some places overtops that of its southern brethren. Like the prairie chickens, the sharptails have retreated before the advance of agricultural development, especially in the United States where the present range is something less than half of its former extent.

The sage grouse, or sage hen, *Centrocerus urophasianus* (Bonaparte), is typically an inhabitant of the sagebrush plains and foothills of the upper region of the Great Basin and the northern Rocky Mountains. Only where sagebrush is abundant do these birds thrive. Overgrazing, hunting, and other factors arising from human habitation have reduced the population by serious proportions, and unless properly protected and otherwise assisted in its struggle to survive, this bird may also suffer the fate of the heath hen.

LIFE HISTORY AND ECOLOGY

Breeding Characteristics. The *sex ratio* of the prairie chickens and the sharptails has never been adequately studied, and few reliable data are available. In the case of lesser prairie chicken, Davison (8) found a decided predominance of males among young birds trapped in late summer. The results of his work are shown below:

Year	Ratio of Males to Females
1933	140–100
1934	146–100
1935	163–100

Whether this relationship is typical of the adult population of this species or of other species of prairie chickens is not known. At least among sage grouse the sex ratio appears to be about even (11).

Breeding Season and Courtship. The breeding season is ushered in by the period of courtship, which is notable for the unusual and spectacular antics of the courting males. At the breeding season, the male birds gather on selected display grounds, known variously as "dancing," "booming," "strutting," or "cackling" grounds, and there carry on their peculiar

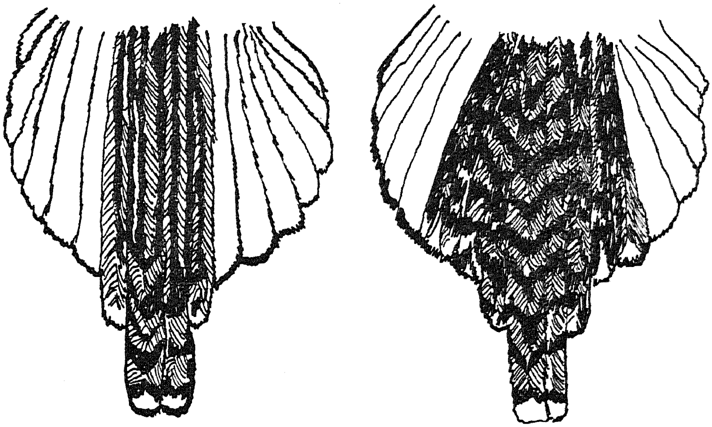

FIG. 10·3. Tail feather markings of male and female sharptail grouse. The markings on the tail feathers of the male are longitudinal, and those on the female are transverse. (*From Snyder.*) (29)

courtship displays. Display grounds vary in size and number according to habitat conditions and the density of population. Some cover several acres (as many as 40 or 50) and accommodate 50 to 100 birds or more. Others are smaller. As few as 5 birds may be sufficient to precipitate the dancing and booming activities, but ordinarily the number is larger. In a survey of 85 dancing grounds of greater prairie chickens in Michigan, the number of birds varied from 1 to 31, with 5 being the most common number observed (9). Observations by Davison (8) over a period of several years suggest that the average number for the lesser prairie chicken is about 10 to 15 males per display ground. Open and reasonably flat but high ground is most often chosen for the booming sites. Unless seriously disturbed by such agencies as fire or persistent agricultural activity, the same grounds are commonly occupied year after year. In fact there is reason to believe that certain of these areas have been in constant use for many decades, perhaps even centuries. However, if preferred grounds are rendered less attractive for some reason or become too small to accommodate all the birds that wish to participate, new grounds are established.

At the height of the mating period courtship is a sight worth seeing. Activity begins early in the morning and continues until just after sunrise, a period generally of 2 to 3 hours (26). In some cases, the dance is resumed again in the evening for a second session of similar length. During these periods the males indulge in a series of dancing and running antics interspersed with booming and cackling calls, which appear to serve as both a challenge to other males and an exhibition for admiring females. The nature of these antics is well described by Chapman (*20 g.r.*) in the following account of the courting of prairie chickens:

At short range the bird's note suggested the mellow resonant tone of a kettledrum, and when bird after bird, all still unseen, uttered its truly startling call, the very earth echoed with a continuous roar. As a rule, each bird had its own stand, separated by about 10 yards from that of its neighbor. The boom is apparently a challenge. It is preceded by a little dance in which the bird's feet pat the ground so rapidly as to produce a rolling sound. This cannot be heard for a greater distance than 30 yards. It is immediately followed by the inflation of the great orange air sacs at the side of the neck, which puff out as quickly as a child's toy balloon whistle; the tail is erect and widely spread, the wings dropped, the neck tufts are raised straight upward, giving the bird a singular devilish look, then with a convulsive movement of the lowered head, the boom is jerked out and at its conclusion the air sacs have become deflated.

One might imagine after so violent a performance the bird would feel a certain sense of exhaustion or at least quiescent relief, but his excess of vitality seeks still other outlets; uttering henlike calls and cacks he suddenly springs a foot or more straight into the air, whirling as though he were suffering from a combined attack of epilepsy and St. Vitus's dance. But all this activity is only a prelude to the grand finale of actual combat. Like a strutting turkey cock, the neighboring birds go toward each other by short little runs, head down, the orange eyebrow expanded and evident pouch inflated, neck tufts and tail straight up, and looking like headless birds with two tails. Their meeting is followed by no make-believe duel but an actual clash of wings. Uttering a low, whining note, they fight as viciously as gamecocks, and the number of feathers left on the ground testifies to effective use of bill and claws.

The booming routine among other species, though differing possibly in certain details, is not dissimilar to the description just quoted above. This activity appears to be greater at certain times than others, however, and on some occasions two rival males may sit on the edge of their respective arenas, their heads almost touching, and glare at each other for long periods without movement.

Paired displays between competing males, whatever form they take, appear to be "duels of personality" (31) to decide which male shall permanently occupy a place on the dancing ground. Eventually, the weaker birds are forced to retreat. Ordinarily, however, neither adversary in a sparring match suffers serious injury (13). It seems highly probable that

these display and competitive activities have a marked influence upon subsequent mating. Scott (27) reports a remarkable example of this among sage grouse in Wyoming. Of 174 observed matings, 87 per cent were accomplished by less than 3 per cent of the male birds present.

The season of the year when breeding takes place and courtship antics are in evidence depends primarily upon latitude and the incidence of warm spring weather. The average season for the various species and subspecies is about as follows:

Greater prairie chicken	April to early June (14)
Lesser prairie chicken	Late February through May (8)
Attwater's prairie chicken	Late January through March (19)
Prairie sharptail	April to early June (14)
Northern sharptail	Late April and May (29)
Columbian sharptail	March and April (*17 g.r.*, 20)
Sage grouse	Late February to mid-May or early June (11, 28)

Leopold (*66 g.r.*) indicates that the various prairie chickens and sharptails are probably promiscuous in their breeding habits. The sage grouse, however, is definitely polygamous (28). The mating procedure of all the grouse and prairie chickens is interesting, but that of the sage grouse is so unusual that it merits a description. The summary is taken verbatim from the article by Scott (28) on this subject.

> The mating habits of the sage grouse were studied for two seasons and for one entire mating cycle lasting from early in March to near the middle of June. The strutting grounds studied, about ½ mile long and 300 yards wide, accommodated 400 cocks and an estimated equal number of hens. An extraordinary system of polygamy prevailed in which dominance in males was based on fighting, bluffing, and strutting display. Practically all mating took place on five mating spots, each not much larger than an ordinary room. Each spot was occupied by a more or less compact group of hens; a dominant, master cock that did most of the mating; his chief rival or subcock that took over some matings under certain conditions, and several guard cocks surrounding the group of hens that aided in keeping intruders away and were rarely allowed to mate with hens. The remaining cocks were on widely distributed locations, singly or in pairs.

With this species the female mates but once to fertilize the eggs for a clutch. A male was recorded as mating with as many as 21 females.

Nesting. The nests of the various species are built on the ground and consist of a shallow depression lined with plant materials and feathers from the parent bird. In the case of prairie chickens the nest is usually placed near a clump of grass. From observations in Minnesota, Cox[1] found that 95 per cent of the nests built by the greater prairie chicken were

[1] Information made available to the author through personal communication with W. T. Cox, St. Paul, Minn., 1941.

located in grassland. Native wild grasses are much preferred to tame grasses, and as a result hay land is a poor nesting ground. Grass and brush are preferred cover for sharptails and the sage grouse. Nesting sites usually occur within short distances of the courtship display grounds, but the sage grouse may go a mile or more. Hamerstrom (15) states that the nests of the greater prairie chicken and prairie sharptail are usually located within ½ mile of dancing grounds and that he found none farther away than 1¼ miles. The females apparently display no antagonism toward one

TABLE 48. INFORMATION RELATIVE TO THE NESTING HABITS OF PRAIRIE CHICKENS, SHARPTAILS, AND SAGE GROUSE

Species	Authority	Locality	No. of nests	Peak of nesting activity	Size of clutch		Days for incubation
					Extreme	Average	
Greater prairie chicken	Gross (13)	Wisconsin	42	Early June	7–17	12	23
Lesser prairie chicken	Bent (*20 g.r.*)	Kansas	4	Early June	11–13	12	
Attwater's prairie chicken	Lehmann (19)	Texas	...	March	.....	12	23–24
Northern sharptail	Bendire (*17 g.r.*)	Not indicated	...	....	7–14		
Prairie sharptail	Gross (13)	Wisconsin	5	Early June	11–17	13	
	Leopold (*66 g.r.*)	Wisconsin	...	....	7–14	12	24
Columbian sharptail	Bendire (*17 g.r.*)	Not indicated	..	Late April	13–15	14	21
Sage grouse	Rasmussen and Griner (21)	Utah	161	April and May	6–9	7	22
	Girard (11)	Wyoming	..	April and May	5–12	.	22
	Bendire (17 *g.r.*)	Not indicated	..	....	7–10	8	20–22

another at this season and may build their nests in close proximity. Leopold (*66 g.r.*) relates an instance where nests built by prairie chickens were so numerous and close together as to be underfoot at "every step."

The length of the egg-laying period appears to vary among the several species and depends somewhat upon the size of the clutch. According to Gross (13), the number of days required for this function by the greater prairie chicken is equal to nearly double the number of eggs laid. However, this correlation evidently is not typical of the sage grouse (21) and therefore should not be accepted for other species until more evidence is available. During the period of incubation, the female leaves the nest only at infrequent intervals, which in the case of the greater prairie chicken (13) occur chiefly at dawn and at dusk. Egg fertility is uniformly high among all species, commonly exceeding 95 per cent on the average. One brood per season appears to be the rule (11, 15, 18), but there are grounds for believing that the female may renest if her first attempt fails. Information relative to the size of clutch, period of incubation, and peak of nesting season is shown in Table 48.

Rearing of the Young. The young birds, which mostly hatch in a very short time once the hatching process begins (13, 18), are brooded by the mother until they are fully dry; then the family leaves the nest and repairs to summer feeding grounds. This group relationship is maintained until autumn, when the broods unite with other family groups to form the large winter flocks that are typical of these birds. The average number of young per brood commonly does not exceed eight and may be fewer in number. Forty-eight broods of Attwater's prairie chickens observed by Lehmann (18) contained an average of between five and six birds. Broods of sage grouse as reported by Girard (11) averaged slightly under eight birds early in the season, while later they had only four birds on the average.

Movements. All the birds under discussion are primarily terrestrial, spending by far the greatest part of their normal existence on or near the ground, both at night when they roost and during the day when they are active. At times, however, certain of the greater prairie chickens and the sharptails may be found in trees, but it is doubtful if other prairie chickens and the sage grouse leave the ground under normal circumstances. The arboreal existence of the first-mentioned birds is limited normally to the winter season, when buds form part of the diet and snow renders movement on the ground more difficult. The greater prairie chickens and perhaps the prairie sharptails sometimes roost in trees during the winter, but more commonly, like the ruffed grouse and other sharptails, they burrow beneath the snow at night, emerging again the following morning.

Seasonal Movements. Except for the Attwater's prairie chicken and the sage grouse, the other birds of this group tend to be migratory in habit. This tendency is especially evident in the greater prairie chicken and to a lesser extent in the sharptails. In parts of their respective ranges these birds are year-round residents, but in the northern reaches part of the population at least moves southward into warmer climates, sometimes covering distances of 200 or 300 miles (1, 29). Among the greater prairie chickens, female birds are more prone to migrate than the males, which either remain in local coverts or move only short distances. As a general rule the northern portion of the prairie chicken range is occupied primarily in summer, the southern limits only in winter, and the central sector at all seasons with the population there consisting both of resident birds and migrants from farther north (15). Migrations among northern sharptails occur more commonly near the peak of the population cycle (29). Aldous (1) reports that the most extended movement of banded sharptails in North Dakota was 58 miles. Other banded birds traveled 31, 7, 6, 4, 2, and ½ miles. The Columbian sharptail is probably somewhat migratory in its northern range, but southward this tendency is not evident. Marshall and Jensen (20) state that in Utah the annual cruising radius of these birds is at most only 2 miles. The lesser prairie chickens, which breed as far north as

southern Colorado, overwinter for the most part in central Texas (*20 g.r.*). As to flight distance, Taverner (*38 Ruffed Grouse*) says that sharptail has reached Isle Royal from the Canadian shore, a flight of 15 miles, and that sooty grouse has flown to the Queen Charlotte Island, a flight of 35 miles.

A shift from summer to winter habitats is also characteristic of the sage grouse but can hardly be regarded as a migration. These birds commonly frequent higher and more exposed situations during the growing season than later, when storms and snow make these locations less habitable than the more sheltered and warmer lowlands. At higher elevations the cover of sagebrush upon which the grouse are so dependent is frequently snow-covered in winter, compelling them to forage lower down in the bottoms and foothills where this condition is less likely to occur. Some of the more hardy birds may move to wind-swept slopes higher up, where presumably the shifting snows leave the sagebrush exposed. At times these seasonal changes of locale are so marked as to suggest a migration; but if such they are, their theater of operations is limited and local (21). In other respects, however, these birds are likely to be more widely distributed in winter than at other seasons, for with snow everywhere present they are no longer dependent upon streams and springs for water. In summer they tend to feed within easy reach of these drinking sites, but in winter they may forage several miles distant (11).

Aside from these migrational movements, there are other seasonal aspects that, though less spectacular, deserve mention. For instance, it is commonly the habit among certain of these birds to retire in winter to situations less open than those occupied in summer. This behavior is doubtless due in part to the better protection afforded by such cover and in part to the browse and other winter food materials that occur there. This tendency to seek out denser cover is particularly evident in species that inhabit regions where wooded types form a prominent element of the vegetation, notably in the range of the sharptails and to a lesser extent in that of the greater prairie chicken. Scott (28) says that male sage grouse may fly as far as 5 miles to and from the mating grounds.

Like many other representatives of the grouse family, the prairie chickens, sharptails, and sage grouse assume a more gregarious existence with the approach of cold weather, a mode of living that is adhered to until the spring breakup just prior to the period of courtship and mating. During this season the family groups band together in packs or flocks that sometimes contain several hundred birds, though commonly fewer than 100. These flocks are often quite active and move about freely in search of food, particularly the prairie chickens, which feed first in one grainfield and then in another.

Spring is the season of mating, and during this period the birds congregate around the dancing and nesting grounds, with the exception of the

sage grouse, which rarely moves any distance. Later, the newly hatched brood and the mother roam the range, leading a leisurely and somewhat aimless sort of existence until fall. The males, following the period of mating, become sluggish and lazy and generally retire to more secluded situations, in particular during the molt in late summer, where they maintain their own counsel in private. Moist, shaded locations near swamps and stream margins are favorite sites for male molting.

Daily Movements. Just as the seasonal behavior of all these birds tends to follow a similar, if not an entirely identical, pattern, so also does the routine of their daily life have much in common. In general, their day-to-day habits follow much the same course. Morning and late afternoon are the principal periods of feeding and drinking; midday is a time for rest. Dusting is also an early morning or late afternoon exercise and rarely occurs at other times. Roosting sites and feeding grounds often occupy different locations, so that flights between these two areas are not uncommon; but otherwise, locomotion is mainly on foot unless the intrusion of an enemy or some other disturbance calls for a hasty departure. The sage grouse is the only exception. These birds, though adapted to an arid habitat, appear to be more dependent upon free water than the others and customarily visit streams or water holes several times daily, often on the wing (11).

Cover Requirements. Habitat requirements of the several birds under consideration, though similar in certain respects, are by no means identical. The chief point of similarity is their common preference for relatively open situations in contrast to high forest areas. In general, it may be said that the favored cover is characterized by herbaceous or low woody vegetation. Certain of the birds are strictly inhabitants of the prairie, and others, though indigenous to forested regions, frequent glades and thickets to a greater extent than adjacent woodland. Winter is the one season when forested situations may play an important role, but even then only the fringes are occupied. Forest serves as a haven against enemies or the forces of nature but little more. Characteristic habitats are open or less heavily wooded. Sharptails more than prairie chickens utilize heavy cover, but even these birds cannot be regarded as true forest inhabitants in the sense that one considers the ruffed grouse or spruce grouse. Despite this mutual preference for relatively open or nonforested situations, the habitat of each species differs sufficiently in floristic composition and degree of openness to set it apart as a distinct, yet related environment.

In connection with cover requirements, the relationships between these grouse and other native grouse are most interesting. Cover preferences among grouse as a group (including species not considered in this chapter) run the gamut from situations predominantly herbaceous to dense forest. Arranged in proper order, they display a very definite and significant transition from one cover type to another. Prairie chickens prefer grasses and

other herbs; sharptails and sage grouse choose shrubby types, low thickets, and forest reproduction; ruffed grouse occur mainly in the hardwood forest; and spruce grouse in the coniferous forest. Each makes sparing use of the class of cover next above or below it in the scale of comparison, but individual preferences for one particular type are clearly evident. This relationship, shown in Fig. 10·4, is well illustrated in any region where the ranges of two or more grouse overlap, as, for instance, in Michigan, Wisconsin, and Minnesota. There, untilled fields and other primarily herbaceous types, such as marshes, admirably serve the needs of prairie chickens. Sharptails utilize such sites on occasion but less consistently than the prairie

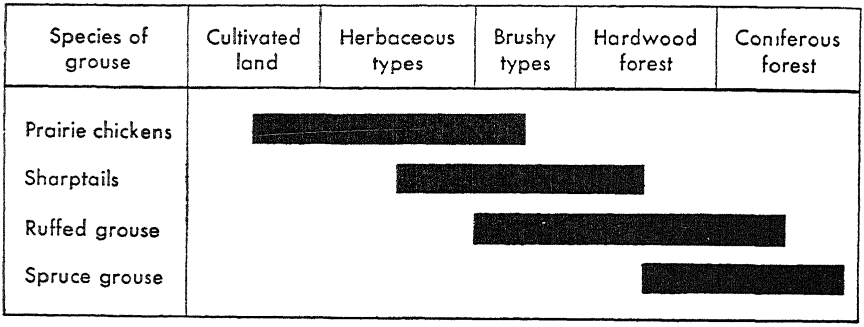

FIG. 10·4. Cover requirements of prairie chickens, sharptails, ruffed grouse, and spruce grouse.

chickens; ruffed grouse, seldom or not at all. As the herbs are gradually displaced by shrub and tree reproduction, prairie chickens move out for the most part and the sharptails move in. And with the eventual successional development of the forest, ruffed grouse succeed the sharptails.

The *prairie chicken*, as previously indicated, is a bird of open grassy situations typified by native perennial grasses, sedges, and other herbaceous vegetation. For short periods in the winter, wooded and shrubby types may serve a limited function but not for long. This is more commonly the case with the greater prairie chicken than its southern brethren, the lesser and Attwater's prairie chickens. The *greater prairie chicken* was found formerly in the tall-grass prairie from Illinois westward to the Great Plains and south to northern Texas (33). Native grasses and forbs were its favored cover. Today, because of altered conditions in this original range, this species has emigrated northward into Michigan, Wisconsin, Minnesota, and southern Canada, where natural prairie is not common. In this region the greater prairie chicken now frequents untilled fields, abandoned farm land as yet not reverted to a brushy condition, and herbaceous marshes, of which there are extensive areas in certain localities, particularly in Wisconsin and Minnesota. Where these birds still survive in their original prairie range, they have retreated from the richer soils,

much of which has been placed under cultivation, to the poorer soils left uncultivated or devoted more to such crops as annual legumes, tame and wild hay, and to pasture lands, as well as in a lesser degree to land used for cultivated crops. This is the condition that prevails in Missouri, where the praire chicken still persists (5, 26).

The *lesser prairie chicken* is found chiefly in the mixed prairie of the high plains region of western Oklahoma and adjacent parts of Kansas, Colorado, New Mexico, and Texas—particularly the last-mentioned state. Bunch grass types appear to be most to their liking, and short grass plains the least. Compared with the greater prairie chicken, habitat of the lesser prairie chicken has less luxuriant vegetation and is more arid, occurring in a region of light rainfall. Preferred cover conditions for the *Attwater's prairie chicken* are the tall grasses of the more humid coastal prairie of eastern Texas and western Louisiana, a type that strongly resembles the true prairie to the north and the former haunts of the greater prairie chicken. Lightly grazed pasture appears to provide adequate cover conditions (19).

Both grazing and the widespread cultivation of land have effectively destroyed much of the range formerly occupied by all three of the prairie chickens. The history of these birds with respect to changes in their natural habitat effected by civilization has been most interesting. Wherever the unbroken prairie was altered to any great degree, causing the native vegetation of tall grasses and forbs to give way to other types, environmental conditions became unfavorable and the birds retreated to more suitable ground. In the case of the lesser and Attwater's prairie chickens there was no real escape; as a consequence the present-day range and density of bird population suffered accordingly. Nor is there much likelihood that the situation will improve appreciably, unless overgrazing with its attendant influx of short grasses or woody vegetation can be effectively controlled. With the greater prairie chicken, however, circumstances have been somewhat different. While settlement and the practice of an intensive type of agriculture evicted them from much of their original range, the development of a less intensive form of agriculture in adjacent lands to the North (an agriculture based primarily on dairy farming rather than tillage crops) created a substitute habitat in a territory that had been uninhabitable previously because of the predominance of forest types in the native vegetation. Thus, though compelled to leave its former range, this bird has now found sanctuary in these more northerly regions and appears to be well established. This emigration to new lands still continues.

The *prairie sharptail*, despite its name, is not found characteristically in grassy situations, even though its extensive range encompasses territory where this type is often dominant. Instead, its customary habitat occurs among the sand hills, in willow and aspen thickets, and on low, rolling

knolls overgrown with shrubbery, forest reproduction, or open woodland. Thus, where the ranges of the greater prairie chicken and the prairie sharptail overlap, the former occurs most commonly in grassland types and the latter in brushy types. As agriculture expands northward, it destroys woody cover conditions that are desirable for the sharptail and creates conditions more suitable for the greater prairie chicken. The effect over a long period of years has been gradually to force out the latter, which then emigrated northward to less thickly settled lands, and to draw in the former.

The requirements of the sharp-tailed grouse as found in Michigan are well described by Baumgartner (4):

> The year-round habitat of the species is characterized by the interspersion of large upland grass openings dotted with small patches of upland hardwoods, poplars and birches, and small bodies of running or standing water bordered by willows and aspens. Sharptails in Michigan seem to require a stage in the plant succession that follows fairly severe fires over large areas. Preferred range reveals a mixture of uplands and lowlands in parts of which soil types will produce a good growth of herbaceous vegetation. They follow the invasion of open grassland by brush and trees. In the course of 20 to 30 years the trees become too dense and the cover too uniform, and the sharptails move out to new range that is more open. At the present time, controlled burning is the only solution that we are able to offer to the problem of improving and maintaining acceptable habitats for this fine game bird in northern Michigan.
> . . . [A] summary of the findings on . . . cover preferences of the Michigan sharptails suggests seasonal habitat requirements and possible management practices. (1) Ideal winter range includes clumps of aspens and white birches bordering open fields and meadows. . . . Open fields, particularly grainfields, furnish considerable waste grain and seeds before deep snows make the ground food unavailable. . . . (2) Preferred mating and nesting areas contain a mixture of open upland ridges and knolls covered with a luxuriant growth of grasses, herbs, and scattered clumps of shrubs and small trees in close proximity to moist or wet willow and aspen thickets or grass bogs. (3) During the early summer the adults stay in the edges of small upland thickets or, more commonly, in the moist willow and aspen draws and swamp borders. In the late summer and fall the old birds move into the uplands and are joined by the young that have spent their first juvenile period in such habitats.

The *northern sharptail*, though more a bird of wooded regions than other sharptails or prairie chickens, is less an inhabitant of the forest itself than of low-growing woody vegetation in and adjacent to it. Thickets about the margins of lakes and bordering agricultural land, open glades, and other sparsely forested areas, such as tracts recently cut over, burns, and muskeg, are the familiar resorts of this bird (*20 g.r.*). Agriculture has left its impress here also. Destruction of the forest within limits has been beneficial, but beyond that point its effect has been largely detrimental. In general,

the settlement of the regions just north of the Great Lakes has favored the northward movement of prairie sharptails and somewhat restricted the range of the northern sharptail. However, there appears to be a definite eastward extension of the latter's range, and both birds have benefited by the abandonment of farm land in parts of the area. As noted earlier, emigrations to new range seem to be most pronounced during periods of high population density.

The *Columbian sharptail* is a western bird that inhabits the grassy plains and benches of interior British Columbia and the northern portion of the Great Basin. Its distribution was formerly considerably more extensive toward the south, but heavy grazing and the accompanying northward march of the sagebrush have destroyed much of the bunch grass prairies without which these birds do not thrive. Remnants of the original range are still to be found as far south as northern New Mexico, and here it occurs most commonly on rock-rimmed, grassy-topped mesas at relatively high elevations (*20 g.r.*).

In summer the sharptails are to be found mostly in thickets or the more open parts of their habitat, but in winter they often retire to wooded situations in search of food and shelter. This habit is most evident with the northern sharptail, which appears to prefer stands of aspen and birch to all others at this season. Where available, this type is also a favorite retreat for the prairie sharptail, while in other localities they frequent willow thickets, alders, and cottonwoods along streams. Bent (*20 g.r.*), speaking of the arboreal habit of these birds in winter, states that they often spend considerable periods in the tops of high trees feeding on buds but at night return to the ground to roost. Sagebrush and low wooded types provide the principal winter cover for the Columbian sharptail. In Utah Marshall and Jensen (20) report that this subspecies prefers grass and grass-weed types in summer, sagebrush or sagebrush and grass during the milder parts of winter, and thickets of bigtooth maple and western black chokecherry in midwinter. It is of interest to note that the latter type occurs commonly at higher elevations than the preceding type.

The *sage grouse*, another bird of the upper sections of the Great Basin, is as its name suggests an inhabitant of the sagebrush plains and foothills. The importance of sagebrush as a part of its environmental complex is shown by Girard's (11) report of studies in Wyoming in which more than 70 per cent of the 1,500 birds that he observed were seen in this type alone. Except when feeding, the sage grouse only occasionally leaves the sage. It is apparent, therefore, that the sage grouse and Columbian sharptail bear much the same relationship as the prairie sharptail and greater prairie chicken. Where their respective ranges coincide, as they do over extensive reaches of the Great Basin, the sage grouse is found in areas predominantly of sagebrush, while the sharptail is found where the cover is more strongly

herbaceous. As noted in the discussion on movements, the sage grouse commonly occupies different range in winter than in summer, being forced to seek out situations where the sage is not covered by snow, *i.e.*, usually at lower elevations but sometimes on upper wind-swept slopes.

Food. Like other representatives of the grouse family, the prairie chickens, sharptails, and sage grouse are primarily herbivores. The noteworthy exception to this occurs in the juvenile stage, when as high as 80 or 90 per cent of the diet may consist of animal matter, mostly insects. The adult diet contains material of animal origin only during the summer and early fall, and then commonly not in amounts exceeding 20 to 30 per cent of the total food intake. The seasonal average of nonvegetable foodstuffs is probably nearer 10 per cent. Insects comprise the bulk of the nonvegetative food—grasshoppers, beetles, and ants being among those most heavily consumed.

The vegetable component of the diet is decidedly variable, and the nature of the materials represented in it is strongly influenced by geographical and seasonal availability. In general, it may be said that all these birds are equipped physiologically to subsist on food in a variety of forms; and as circumstances dictate, they consume foliage, seeds, fruit, or browse. The character of the diet therefore varies with the season. During the vegetative period it consists first of succulent foliage and later of foliage, seeds (including domestic grains), and fleshy fruits, with greater amounts of seeds and fleshy fruits being consumed than foliage. In winter these same materials are eaten where available and are supplemented by browse (buds, twigs, catkins). Browse, regarded in this sense, is almost exclusively a winter food.

The importance of grain in the diet of these birds is dependent upon the species in question in addition to the geographical locality involved. All these birds were most certainly granivorous; even before the advent of man, the luxuriant native grasses of that period provided seed in abundance. With the introduction of domestic grains, however, this natural supply was considerably augmented, and today cultivated grains are much sought after, especially by the prairie chickens and the Columbian sharptail. Such grains are most important as fall and early winter foods and again in early spring just after the snow has melted. Their consumption is not necessarily essential, however, except where native food materials are scant. As winter approaches, it is a common sight to see large flocks of prairie chickens feeding in the fields, gleaning the waste kernels left from harvest. Corn, buckwheat, soybeans, and oats are the favored foods in this category. Wheat, rye, and other grains, though frequently consumed in quantity, appear to be less preferred. Corn plays its greatest role mainly in the corn belt through Illinois, Missouri, Iowa, and southern Wisconsin. Farther north where corn is planted less extensively, buckwheat, wheat, and other small grains take its place. Wheat is the principal grain on the range of

the Columbian sharptail. Among the northern sharptails, none of these materials is of importance, for in much of its range settlement is sparse and agriculture poorly developed (30). The prairie sharptail occupies an intermediate position. It relies upon grain to a considerably greater degree than the northern sharptail, but less so than the prairie chicken. Aldous (1) states that the autumn food materials of the sharptails in the North Dakota sand-hill region include insects, weed seeds, small grains, and some buds, while the bulk of the winter food consists of buds, including those of willow, poplar, cherry, and Juneberry.

The importance of browse, like that of grain, varies with locality and the species of grouse in question (12). Browse is of vital importance as an essential constituent of the diet only in those regions where winter conditions are such that other materials are not available in sufficient volume to tide the population over until spring—mainly, therefore, among the sharptails and the sage grouse, the latter and the northern sharptail in particular. It is evident, however, that the sharptails tend to browse in midwinter whether other foods are available or not, hence browse must be regarded as a staple part of their diet at that season. This is true likewise of the sage grouse. On the other hand, prairie chickens and probably the Columbian sharptail also utilize browse freely only when forced to it. These species continue to feed upon grain and other nonbrowse items as long as conditions permit. Since snow is usually present throughout the greater part of their range, greater prairie chickens commonly browse during short periods nearly every year. Attwater's and lesser chickens in contrast do so only at infrequent intervals. The principal browse plants are paper birch, aspen, balsam poplar, cottonwood, and willow. The relative importance of browse, grain, and other classes of food materials is presented in Table 49. For purposes of comparison the ruffed

TABLE 49. THE FOOD HABITS OF CERTAIN GROUSE AS SHOWN BY STOMACH ANALYSIS (*58 g.r.*)

Type of food	Per cent of total		
	Ruffed grouse	Prairie sharptail	Greater prairie chicken
Fruit	28.3	27.7	11.8
Mast	5.3	7.4	
Miscellaneous seeds	6.5	.....	14.9
Grain	.....	20.5	31.0
Browse and miscellaneous vegetable matter	49.0	34.2	28.2
Insects	10.9	10.2	12.8
Miscellaneous animal matter	. . .	.....	1.3
Total	100.0	100.0	100.0
No. of stomachs analyzed	208	43	71

grouse has been included. Preferred winter foods of the prairie sharptail, northern sharptail, and greater prairie chicken are shown in Table 50.

The *Attwater's prairie chicken* (19) derives most of its food from native plants, but to some extent also from agricultural crops. Ruellia wild petunia is the most important single item. Star grass, bedstraw, doveweed, and perennial ragweed are others eaten freely over long periods. Nearly all these materials grow naturally in moderately grazed pastures, which

TABLE 50. WINTER FOOD PREFERENCES OF PRAIRIE SHARPTAILS, NORTHERN SHARPTAILS, AND THE GREATER PRAIRIE CHICKEN (22, 23)

Food classes	Prairie sharptail	Northern sharptail	Greater prairie chicken
Preferred foods (eaten mostly before snow falls)	Buckwheat Corn Soybeans Oats Sheep sorrel Acorns Clover leaves	Fleshy fruits (especially blueberries, cherry, mountain ash, rose, dogwoods, and viburnums) Seeds of grasses, sedges, and weeds	Buckwheat Soybeans Barley Oats Ragweed Smartweed Acorns Rye Climbing false buckwheat
Staple foods (eaten mostly after snowfall)	Paper birch browse Bog birch browse Aspen browse Leatherleaf leaves and browse Willow browse Cedar berries Cottonwood browse	Paper birch browse Mountain ash fruit and browse Aspen browse Willow browse Blueberry browse Hazel browse Alder browse	Corn Hazel browse Paper birch browse Bog birch browse Aspen browse Black birch browse

form the principal habitat of this subspecies. Of the cultivated plants, those consumed in quantity are peanuts, hegari, and rice. Browse is of no importance.

The Columbian sharptail (20), like the greater prairie chicken, is highly granivorous. Wheat is the preferred grain, but other domestic plants such as alfalfa and sunflower are important items—the former in the spring and the latter in the fall. The seeds and blades of various grasses, dandelion, dock, and yarrow and the seed heads of sagebrush are the principal native food plants. The last, together with browse such as big-tooth maple and chokecherry (in Utah), are staple materials during winter.

The sage grouse (11, 21) is almost wholly dependent upon sagebrush, not only for cover as stated earlier, but for its food supply as well. Between 70 and 80 per cent of its diet is obtained from this source. Moreover, it is eaten at all seasons, and virtually all parts are edible—small stems, twigs,

leaves, flowers, and fruiting heads. Only in late summer are other materials represented in quantity, and even then the well-nigh ubiquitous sagebrush comprises at least 30 per cent of the total diet. Of these other plants, the most important are clover, dandelion, miscellaneous grasses, and species of the buttercup family. Ants, cricket eggs, lice, aphids, scale insects, and beetles are the principal sources of foods of animal origin (17).

Water. The question as to whether the species of grouse under discussion are dependent upon free water for drinking purposes is a matter that appears to have merited but little attention, and almost no reference to this subject is to be found in the literature. Leopold (*66 g.r.*) is of the opinion that "grouse as a group seek and may require drinking water in late summer and . . . in droughts." But it is entirely possible that succulent foods such as green leaves and fleshy fruits may serve as a satisfactory substitute, since this is known to be the case with many other game birds. Aldous (1) says that sharptails need moisture other than supplied in the food and reports one bird eating snow. In any event, the question is perhaps more academic than practical, except on arid ranges such as those occupied by the lesser prairie chicken, the Columbian sharptail, and the sage grouse. Concerning the water requirements of the first two species, nothing has been published to the author's knowledge. With respect to the last, reports leave the question unanswered. Girard (11) evidently believes that water in the free state is an essential part of the environment; Rasmussen and Griner (21) imply that it is not.

Grit. Like the question of water requirements, the need for grit in the "food diet" has received little study. It may be taken for granted that grit in some form is required except in the case of the sage grouse, which is unique among grouse in having no gizzard. Gravel is doubtless the most suitable grinding material. Whether or not hard-coated seeds and fruit stones serve as substitutes has not been satisfactorily determined. Frequent reference (*17 g.r.*, *20 g.r.*, 22) has been made to the possible use of rose hips for this purpose. In this connection, it is well known that both the greater prairie chicken and prairie sharptail consume these fruits in considerable quantities during seasons when the supply of gravel is limited.

Population Density. Statistics concerning populations of prairie chickens, sharptails, and the sage grouse are scattered and difficult to evaluate in favored locations. Before the advent of man on the prairie, prairie chickens were found in great abundance. Bags of 50 or 60 or even 100 in a day were common in Illinois before 1850 (23). Schorger (23) quotes Newell (before 1897) as seeing on the average four nests of prairie chickens to the acre in northwestern Iowa. Such data as are available appear in Table 51 and apply to what the several authors listed regard as good range conditions. For average conditions over extensive areas the population densities are lower.

Like the ruffed grouse, at least certain of the birds under discussion are subject to *cyclic fluctuations* in population density. It is agreed that this phenomenon is strongly evident among northern sharptails and to a lesser extent among prairie sharptails and greater prairie chickens (23). In the case of the last two species, the tendency is probably strongest northward. Criddle (7) found that in the 35-year period from 1894 to 1930 the numbers of northern sharptails had passed through three periods of rise and fall. The year 1932 also marked a peak in the cycle, followed in the autumn by a

TABLE 51. SAMPLE RECORDS OF POPULATION DENSITIES FOR PRAIRIE CHICKENS, SHARPTAILS, AND SAGE GROUSE ON GOOD RANGE

Species	Investigator	Locality	Birds per square mile
Greater prairie chicken	Yeatter (32)	Illinois	40–50
Greater prairie chicken..	Bennitt (5)	Missouri	15
Greater prairie chicken and prairie sharptail . .	Hamerstrom (14)	Wisconsin	65
Lesser prairie chicken . .	Davison (8)	Oklahoma	35–70
Attwater's prairie chicken	Lehmann (19)	Texas	65
Sage grouse	Rasmussen and Griner (21)	Utah	125
Sage grouse.....	Girard (11)	Wyoming	250

very considerable emigration of these birds from the region around James Bay to the south and southeast (29). Whether or not cyclic fluctuations are characteristic of other species in this group, the author does not know. No evidence is available on the cyclic fluctuations by lesser and Attwater's prairie chickens.

MORTALITY

Mortality before Hatching. Nesting mortality, as with most ground-nesting birds, is high. Recorded accounts suggest that on the average it is rarely less than 30 per cent and sometimes in excess of 60 per cent or even more. Gross (13) reports a loss of 50 per cent among nests of prairie chickens and sharptails in Wisconsin. Flooding, carnivores (dogs, mink, coyotes), and crows are principally responsible. Of 114 prairie chickens' nests studied by Hamerstrom (15), 46 per cent were failures; and of 54 prairie sharptails' nests, 30 per cent failed. Among Attwater's prairie chickens, losses may amount to 60 to 70 per cent (19). In the case of this bird heavy rains appear to be a most important mortality factor, often flooding extensive areas of low ground and thus destroying nests or newly hatched young. Lehmann (19) estimates that the increase in population is about 100 per cent when the precipitation for May (the crucial month) is subnormal by 1 inch. He also states that the increase is only between 35

and 65 per cent when rains are normal and that it is even more adversely affected when rains exceed normal. Skunks and opossums are the chief mammalian predators of Attwater's prairie chickens. Losses are also high among nests of the sage grouse. Nests under observation by Rasmussen and Griner (21) were on the average 40 per cent unsuccessful. Twenty-six per cent were destroyed, mostly by coyotes, skunks, weasels, and ravens, and 14 per cent were deserted, human activity being the main cause of this latter loss. Allred (2) found a loss of nearly 81 per cent of 21 nests inspected. In this instance ravens and coyotes were found to be the principal predators.

Losses Due to Predation and Miscellaneous Causes. Mortality caused by predation has not received the intensive study that the subject merits. In the few cases where work of this nature is being carried on, findings have not as yet been published. The following have been listed by various authors as possible enemies of the various species of grouse under consideration: feral house cats, dogs, coyotes, skunks, weasels, ravens, owls, eagles, and hawks (goshawk, duck, Cooper's, marsh, rough-legged, Krider's, red-shouldered, and Sennett's white-tailed). To this list should be added the fox and the bobcat, both of which probably prey upon northern sharptails. It is an open question just how truly destructive any of these alleged predators are. All of them without doubt are capable of destruction, but the evidence against them as reported in published accounts is not an especially convincing indictment. With respect to the marsh hawk, it is interesting to note that two competent observers (25) report that although these birds often persistently harry prairie chickens, they apparently make no effort to capture them. Cooper's hawks and red foxes take prairie chickens occasionally, but man is the only important cause of predation in Missouri according to Schwartz (26). Scott (28) speaks of the loss of sage grouse by eagles and also because of collision of this grouse with fences or other wire obstructions.

The effect of heavy rains and the flooding of mating grounds has been mentioned earlier in referring to the Attwater's prairie chicken. This factor, linked with cold weather, is also detrimental to young broods of the greater prairie chicken (13); it doubtless exerts a decimating effect upon other species of grouse as well. Severe winter weather is another factor with which these birds must cope, and losses from low temperatures, wind, and sleet are probably of considerable importance, especially among the species inhabitating northern regions. Birds roosting beneath snow constantly run the danger of being imprisoned by the formation of crust overhead or killed by foxes and coyotes which come upon them in the night in snow roosts. Food shortages are most acute at this season, and there is little reason to doubt that death from undernourishment may be an important factor in the mortality northward.

In certain regions fire is a destructive element of unquestioned effect. The habit of burning pasture to encourage the development of spring grasses destroys a great many nests and young broods and by removing the cover of old grasses renders such sites at least temporarily less attractive. Burning of prairie land is an established practice in the South. Even farther north it is not uncommon. Overgrazing and the production of tillage crops also have an important bearing on natural losses. Though not directly responsible for destroying any appreciable number of birds, these two factors more than any others have restricted the area of suitable cover and thereby reduced the productive capacity of the range. A limited amount of cultivation and regulated grazing is not entirely detrimental and in fact may even prove beneficial; but where intense cultivation and overgrazing are common over an extensive acreage, the effects on the grouse range are not good. Overgrazing destroys cover, eliminates certain plants, and introduces others, and in most cases those which invade the overgrazed areas are less to be desired than the vegetation replaced. For example, development of mesquite and other shrubs on grasslands in Louisiana and Texas and of sagebrush in the Northwest is due in large part to long-continued abuse of the land, of which overgrazing has been a major factor. Unfortunately, it is still operative.

Excessive hunting has been one of the foremost causes of the decimation of these species of grouse, in much the same way as it has been with many other kinds of wildlife that once were abundant but since have fared badly. This was particularly true of the indiscriminate killing in earlier days, when both prairie chickens and prairie sharptails were slaughtered in almost unbelievable numbers, partly for market but not uncommonly just for "sport," so-called. As an illustration of this wanton destruction, Lehmann (19) states that in former times when Attwater's prairie chickens were plentiful, hunting parties of 10 to 20 often encamped for periods of several days on good range and held contests to determine who could bag the most birds. At the end of the encampment period the dead carcasses left to rot frequently numbered 1,000 birds or more. Is it any wonder that until recently this bird was in imminent danger of suffering the fate of the heath hen! This is just an example. Other species of grouse were doubtless killed with equal abandon. Fortunately, state conservation departments have now limited the hunting privilege, and the menace of extinction from this cause is less acute.

MANAGEMENT

Census Methods. Census counts to determine the population density can be accomplished in a number of ways. Three methods are worthy of consideration; and although these are not productive of wholly accurate results, they are the most satisfactory yet devised. The most nearly per-

fect method—but also the most expensive—is the *complete census.* This procedure, as its name implies, is simply a painstaking examination of the entire area in question, the object being to cover it thoroughly and thus flush all the birds present. The use of trained bird dogs is of great assistance. In open country where visibility is good and terrain relatively unbroken, a more rapid coverage can be effected by riding a horse. However, where dogs are employed, this means of locomotion is probably not always practical. For additional information concerning the complete census the reader is referred to Chap. IV, *Pheasants.*

Lehmann (19) developed a variation of the preceding method that he calls a *rope count.* Fundamentally, it is a complete census, differing from the usual conception only as to the details of procedure. Under conditions typified by the coastal prairie habitat of the Attwater's prairie chicken, it has proved highly successful as to both accuracy and economy. In essence, it consists merely of "dragging" the census area with a strong rope or wire cable stretched on swivels between two automobiles. The rope rides (literally rolls) over the intervening ground between the cars, flushing the birds en route. Half-inch Manila rope or one-quarter-inch steel cable is strong enough to serve the purpose. In length it should be between 60 and 120 yards. The area to be covered is traversed in parallel strips at speeds of from 5 to 15 miles per hour. Two thousand acres a day can be covered in this manner. All types of grassland cover encountered on the range of the Attwater's prairie chicken has been surveyed by this method. To avoid injury to nests or young broods, this method should be employed after the nesting season. Its limitations on rough or brushy land are obvious.

A rapid but less accurate estimate of population can be obtained by a *count of booming males.* This requires prior knowledge of display grounds and usually necessitates the construction of blinds from which to view the booming activity. Blinds are not always needed, however. Lehmann (19) drove to the display grounds in an automobile and made his observations without leaving the car. The dancing birds usually ceased activity when he first approached but resumed the dance a few minutes later. In this manner, he covered the display grounds on 2,000 acres in a single morning and by repeating the count for several days secured a reasonably reliable census of the male population. Determination of the total population by this method depends on knowing the sex ratio. When the ratio is not known, as is usually the case, approximate results can be obtained by proceeding on the assumption that the numbers of males and females are equal.

Food and Cover Development. The recommendations that follow are of necessity somewhat more generalized than is perhaps desirable. This situation is caused in part by a paucity of knowledge concerning the best

methods of managing certain of the less well-known species, especially the sage grouse and Columbian and northern sharptails. To treat in detail the problem of habitat improvement for seven different birds requires more space than can be justified.

1. *The development of food patches.* Winter is the critical period in the life of all species of grouse in so far as their food supply is concerned and particularly on those parts of the range where snow is present during winter. At other seasons forage is generally abundant, but in winter green foods become decidedly scarce or even lacking altogether. If deep snows cover grain and weed seeds, browse may be the only source of food available. Furthermore, the tendency among certain of these birds to rely upon cultivated grains as their winter staple has to a degree dulled their ability to subsist without it. This is particularly true of the prairie chickens. Thus, when for any reason, such as a month of heavy snow, these materials are not available in the customary quantities, the prairie chicken population is frequently hard pressed to secure adequate food. The establishment of food patches is therefore a most excellent method of carrying the resident population through the winter in a healthy state.

Buckwheat, soybeans, oats, corn, clover, German millet, dwarf milo, and hegari are recommended for this purpose. Corn is perhaps the most palatable of these and is the ideal reserve food supply for states in the corn belt. For maximum effectiveness the corn should be shocked in the fall. The various species of grouse are less inclined to enter a field of uncut standing corn than one where the corn has been shocked or partially trampled down (22). Farther north, buckwheat, soybeans, and oats have been used with satisfactory results. Soybeans have the advantage over buckwheat of being stiffer stemmed and hence less likely to lodge in winter. Planting the two in mixture is often a desirable practice, as soybeans tend to hold the weaker buckwheat upright. Planted alone, buckwheat should be sown broadcast. Soybeans produce better if planted in rows. In mixture they may be sowed together broadcast, but preferably the soybeans should be placed in drills and the buckwheat broadcast between. German millet, dwarf milo, and hegari are recommended for planting on range of the Attwater's prairie chicken (19). For advice as to suitable varieties, time of planting, use of fertilizer, and quantity of seed for sowing, the best procedure is to consult a local agricultural extension service or experiment station.

To be most effective, food patches should contain at least an acre, and areas up to 10 or even 20 acres are not always too large. On the range of the prairie chickens a patch of the maximum size may be sufficient to serve the entire population for several miles around. Unlike certain other game birds such as the pheasant or bobwhite, which have a limited cruising radius, the prairie chickens tend to be more active and often travel a

considerable distance in their search for grain during the winter season. For this reason a few large plots rather than many small plots may suffice. On the range populated primarily by sharptails, patches should be smaller and more numerous. Patches placed near thickets or similar protective cover are likely to attract more birds than patches surrounded by open fields or stubble. In the case of sharptails it is important that the patches be located in "back" country where human habitation is not common (22). These are the places where sharptails are most abundant and most in need of fall and early winter foods. Whereas prairie chickens seek out grain even in a heavily farmed territory, sharptails on the other hand tend to avoid such sections and are limited to more remote localities in their feeding upon cultivated crops.

2. *Development of winter browse plants.* This aspect of habitat improvement is concerned primarily with encouraging the establishment and growth of aspen, cottonwood, paper birch, willow, balsam poplar, and perhaps hazel. Sharptails more than prairie chickens tend to profit from efforts in this direction. Willow and cottonwood occur typically on the wetter soils along watercourses in the prairie region, and on these sites their establishment and subsequent survival require the minimum of encouragement. If allowed to develop naturally such areas ordinarily produce the desired type of vegetation without much assistance. Aspen and birch are upland species that grow to best advantage in the northern Lake states and throughout the range of the northern sharptail in Canada. In most of this region aspen and birch are often the principal species to revegetate new burns and cutover land that has been clear cut. Once established, they grow rapidly and generally maintain a dominant position in the stand for 30 to 50 years. Thereafter, they tend to be replaced by more shade-tolerant trees, which develop first as an understory and eventually work their way upward through the overhead canopy. Periodic clear cutting followed by treatment to relieve competition from other species is sufficient to maintain a satisfactory stocking of either aspen or birch. Applied strictly as a measure to provide browse, treatment of this nature is necessary only along woodland borders and not in interior portions. Neither sharptails nor prairie chickens venture into heavily timbered areas farther than the marginal fringe. Thus, where it is desirable to devote the major part of a stand to the production of forest crops other than aspen or birch, this can be accomplished without serious interference with or from the development of a browse supply. In short, only the border of a wooded tract need be managed for the benefit of these species of grouse; the remaining portion can be handled in whatever manner seems best for the particular goal of forest management.

The development of hazel as a browse supply is recommended for prairie chickens only. Schmidt (22) has advised the use of this species in hedges.

In the northern prairie district through Alberta and Manitoba, a suitable browse reserve can be developed of balsam poplar.

Browse plants of low stature are superior to tall trees, and for this reason areas devoted to browse production should be cut back frequently enough to maintain the vegetation in a youthful condition. Grouse are not entirely adverse to feeding in larger trees; but being more terrestrial than arboreal in habit, they prefer vegetation nearer the ground. A sapling strong enough to support the bird while it feeds is excellent.

3. *Emergency feeding.* Emergency feeding becomes necessary when normal food supplies are insufficient. In the course of an unusually severe winter, resort to this practice may be the only way to avert starvation. Under ordinary climatic conditions, however, emergency feeding has no place in a permanent plan of winter feeding. If during normal seasons frequent recourse to the use of emergency rations becomes necessary, a fundamental weakness in the management program is evident. Corn appears to be the most satisfactory grain for this purpose. Schmidt (22) recommends that it be placed on raised platforms.

4. *Development of cover in the form of native grasses and thickets of low shrubs.* Improving cover is important chiefly in the more thickly settled districts where agriculture, especially intensive agriculture, has converted large areas of prairie to cropland. Where this has taken place to the point that native cover is largely destroyed, bird populations are either sparse or lacking altogether. On soils well adapted to highly productive farming there is little likelihood that this situation can be altered sufficiently to effect a significant improvement. Such lands are too valuable to be removed from crop production. But on marginal and submarginal lands the situation is different. These soils are not suited to intensive agriculture and may well be restored to their former untilled condition. Permitting such lands to revert to their natural state increases the area of habitable grouse range. Reversion to native grasses favors the prairie chickens; thickets favor the sharptails. In regions where forest is the type of vegetation that ultimately develops if given the opportunity, maintenance of grassy openings or heathlike cover requires continued treatment. Otherwise, these places seed into trees and soon become too heavily wooded to support a sharptail or prairie chicken population. Moderate grazing or controlled burning are both practicable ways in which the maintenance of grassy openings or heathlike cover can be accomplished (4).

5. *Development and maintenance of booming grounds.* Ideal display grounds are open lands free from woody vegetation. Breeding can be encouraged if these areas are treated at intervals to maintain them in an open condition. Small booming grounds can be enlarged if conditions warrant, and in some cases it may be desirable to develop wholly new dancing sites.

6. *Control of grazing.* Except for widespread tillage of the land, no

factor is so detrimental to grouse range in general as overgrazing. Heavy grazing eliminates all but the most inaccessible or browse-resistant plants, thus reducing the volume of available food materials. Closely cropped pasture or range land provides a near-minimum of conditions suited to grouse habitation. The effect of moderate grazing is in marked contrast. Moderate grazing seriously impairs neither cover nor food supply; and in locations where natural growth is more dense than desirable, it serves to alleviate the situation by introducing the necessary degree of diversification.

7. *Control of fire.* The burning of prairie land should be eliminated wherever practicable. If this practice must be used, it should be carried out before nesting commences in the spring. If pastures are to be burned along the coastal prairie in Texas, Lehmann (19) recommends that it be completed by Feb. 1, conducted only under proper supervision, and done on days when the dead grass is damp. Burning of drained marshlands in central Wisconsin should be prevented if possible. Often the only means of accomplishing this is to plug drainage ditches and raise the water table. Preventing the burning of prairie grasses is recommended in Minnesota to encourage habitation of wastelands by prairie chickens (6).

8. *Development of refuges.* Refuges are recommended for the Attwater's chicken (19) and the sage grouse (11). Areas reserved for refuges should contain about 10,000 acres. Grazing, burning, and hunting must be excluded, and the establishment of food patches is highly desirable. For the sage grouse Girard (11) advises plots of clover and dandelion established in the ratio of 10 acres for every 800 birds supported by the refuge. Although the development of a refuge system is most needed among species that border on extinction, other species not so endangered also benefit from the practice. The use of refuges is an excellent means of building up populations in sparsely occupied territories.

Miscellaneous Management Procedures. *The sex of sharptails* is difficult to determine. As seen in the wild, males and females look alike. The chief difference lies in the pattern of dark bands and blotches on the tail feathers (29). On the male, these markings run mostly lengthwise of the feather and appear primarily on the middle four feathers. On the female in the main they take the form of transverse bands and occur on six to eight feathers. This difference in color pattern is especially noticeable on the two central feathers, somewhat less so on the others.

The *trapping* of live birds has been accomplished successfully with several trapping devices. The tiptop, funnel, cloverleaf, and bob-wire traps all serve the purpose well. The last one is fully described and illustrated in the chapter on *Ruffed Grouse.* This device (16) is simply a mesh-covered frame having an entrance blocked off by "bob wires," so-called. These are stiff pieces of wire (No. 9 has been recommended) suspended from a

rod, bar, or other arrangement at the top of the entrance and extending downward to a point inside and just below the bottom sill of the cage. They are unattached at the lower end and thus free to swing on the support above. They may be pushed inward by a bird attempting to enter the trap, but not outward, because the wires are too long to clear the sill. The wires should be placed close enough together to prevent the captive birds from squeezing through. Aside from the entrance, the trap is not unlike many others. Its dimensions may be large or small, except that in height it should measure at least 14 inches. Netting in the top of the trap prevents serious injury to the birds that attempt to escape by flying upward. Corn (either shelled or on the cob), soybeans, and buckwheat have given satisfactory results as bait for these traps.

Restocking of areas that appear to be suitable for sharptails is being tried with some success in Michigan. Trapped birds are being released in widely scattered locations. Nests and broods of released birds have been observed. With control of their hunting it is hoped these birds will repopulate much of the northern Michigan grouse range (10).

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CHAPTER XI

RUFFED GROUSE

Bonasa umbellus umbellus (Linnaeus)

GEOGRAPHICAL DISTRIBUTION

The mixed woodlands of Northern and Eastern North America are the home of our most interesting game bird, the ruffed grouse. This bird gets its name from the ruff of dark feathers on its neck, which may be displayed by either sex, but more commonly by the male. The sound of a drumming grouse in our Northern forests is as much a harbinger of spring as is the song of the spring peeper or the music of the song sparrow. Everything about the grouse merits our admiration. It lives gloriously and embodies all of the qualities we cherish: skill, cunning, strength, speed, grace, courage, and love, all intense in quality and developed to a high degree. As a game bird it is unexcelled.

The range of the ruffed grouse is extensive, reaching across the continent from the northern limits of forest growth southward to northern California on the Pacific coast, to northern Utah in the Rocky Mountains, to the Great Lakes region, and along the Appalachian Highlands to northern Georgia. Formerly, the Southern extension of its range included most of the Central states from Arkansas northward and large sections of the RockyMountains and the Pacific Northwest. Remnants of the population still remain in these regions as isolated units, but the extensive clearing of forest lands and other factors have caused the range as a whole to recede gradually to more heavily forested sections. At present this recession has ceased for the most part; and in certain localities where the abandonment of agricultural land has been common, the trend is now reversed and the range is expanding. Moss (32) found that in Connecticut the kill of grouse increased from 0.5 bird per licensed hunter in towns 20 per cent forested to 1.3 birds per hunter in towns 80 per cent forested.

LIFE HISTORY AND ECOLOGY

Breeding Characteristics. *Mating.* The familiar thump, thump, thump of the season's first drumming male ushers in the mating period. The normal period of drumming extends from late February to late June

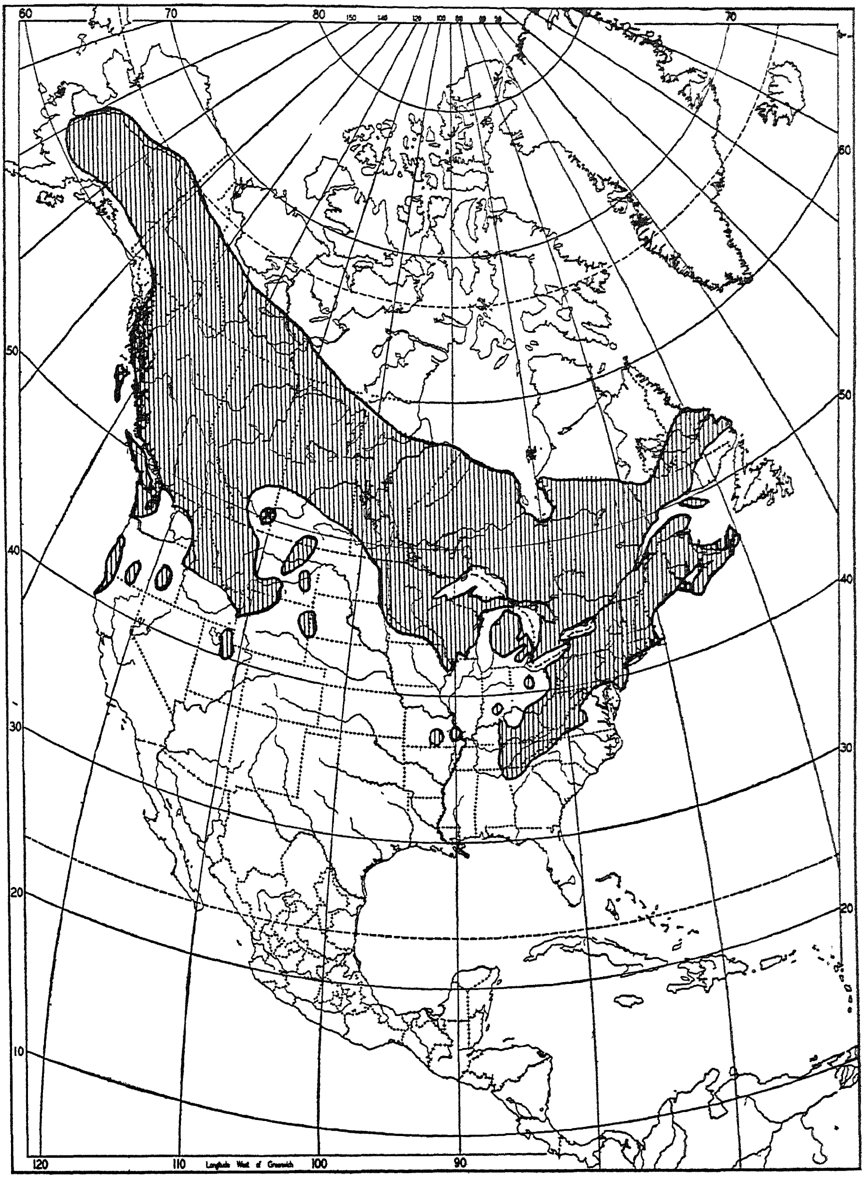


FIG. 11·1. Range of the ruffed grouse. (*Range in the U.S. by Robert C. McClanahan,* 1940, *and Canadian range by C. H. D. Clarke, Toronto, Canada,* 1941.)

in the Lake states (*7 g.r.*) and from Apr. 1 to late July in New England (*41 g.r.*) and Ontario (11).

The purposes of the drumming of male grouse and the changes that the

drumming males undergo as the season advances are not well understood. In its early stages drumming appears to be principally a challenge directed at all and sundry, whether male or female, and has the effect, according to Allen (2), of intimidating the weaker members of both sexes, which are frequently frightened away. The challenging effect of early drumming was demonstrated to the author near New Haven, Conn., by Professor Ralph C. Hawley of Yale University who attracted a male bird, obviously in a belligerent mood, out of a wooded cover into the open by running his automobile motor at a low speed with the spark retarded. Thumping the chest to simulate drumming has the same effect (42).

Later, drumming appears to be the prelude to the act of mating and is an essential part of courtship. Certain females, and they may number more than one (*41 g.r.*, *66 g.r.*), are attracted to the drumming site. Those which are not intimidated and scared away by the behavior of the male remain in the general locality and return to the drumming log periodically. Eventually, the mating instinct develops in the male; and after the usual courtship antics, the mating act is consummated.

Drumming is generally carried on from the top of a large log or sometimes from a boulder or stone wall. In New Hampshire 59 per cent of 46 drumming birds were using rocks ranging in size from a small dome a few square inches in area to boulders as large as 15 feet long, 4 feet wide, and up to 4 feet high. No log less than 13 inches in diameter was used (25). While the drumming site is more commonly a partially rotten and moss-covered log, a newly felled tree may also be used. The same log may be used year after year. Ordinarily, the drumming site is well concealed behind a protecting screen of low-growing vegetation. Investigations now in progress in New York [1] show that drumming logs tend to be concentrated in certain localities and entirely lacking in others, but the factors that contribute to this condition (probably a matter of cover) are not yet fully explored. Under New Hampshire conditions only 15 per cent of drumming locations were on north, northeast, or northwest slopes. Most of the locations (72 per cent) were in younger stands containing conifers. A decided preference was shown for ground cover containing a few key plants. The most common species were bracken fern, sweet fern, checkerberry, pine seedlings, club mosses, and running blackberry.

Early morning is the customary period for drumming, and at that time it may be nearly continuous. Later in the day this activity occurs but intermittently or ceases altogether, but sometimes a bird will drum at night. Drumming out of season, which occurs occasionally during late summer and early fall after the mating period is over, is variously attributed to par-

[1] Work carried on by W. L. Webb, Roosevelt Wildlife Forest Experiment Station, Newcomb, N.Y.

ticularly vigorous adults that "don't know when to quit," and to juvenile birds beginning to "feel their oats."

The *sex ratio* tends to favor the males slightly, to judge from the few data available. Of 295 birds examined in New York by Edminster and his coworkers (19), the ratio was approximately 52 males to 48 females. Bump (10) published a summer ratio of 57.5 males to 42.5 females, as calculated from examination of adult grouse in Connecticut Hill, N.Y., from 1930 to 1942. The sex ratio is apparently variable with cycles of abundance, males predominating during the low of the cycles (*66 g.r.*)

Nesting. The grouse is typically a bird of the forest with its nesting habits reflecting this choice of cover to a marked degree. The nest itself is a simple depression on the ground lined with vegetative debris. Hardwood leaves are the customary materials, but needles of conifers also occur where evergreens are present in the forest cover. The edge of cutover areas where slash is abundant and forests of hardwoods (9), especially immature stands and older stands having a well-developed understory, are favorite nesting sites. Nests are commonly located under the fringe of brush piles and at the base of trees among the root swells. The choice of nest cover varies in different localities, however, a fact substantiated by the location of nests in New Hampshire, where only one of four nests on the average was in hardwoods.

The average clutch (see Table 52) of about 10 to 12 buff-colored eggs (some of which are slightly spotted) is laid in from 2 to 3 weeks. The maximum productivity of healthy females is considerably greater than the average clutch indicates, however. Several investigators report maximum clutches containing 23 to 27 eggs. A female grouse examined by the author contained 92 primary oocytes.

TABLE 52. SUMMARY OF DATA CONCERNING SIZE OF CLUTCH

Investigator	No. of nests	Location	Average clutch
King (*66 g.r.*)	. . . . .	Minnesota	12.5
Schmidt (*66 g.r.*)	. . . . .	Wisconsin	11.5
Fisher (21).	9	Michigan	10.5
Bump (6, 7).	1,003	New York	11.0
Studholme (37).	16	Pennsylvania	11.0

Nest building and incubation are wholly functions of the female; for once mating is over, the male displays but little interest in the activities of the female or her brood. Incubation normally requires from 21 to 28 days. Under favorable circumstances, the usual period is 24 days or less. When the weather is cold and wet, or if the sitting bird is frequently dis-

turbed from the nest, the incubation period is lengthened. Fertility is high according to Edminster (15), who stated that about 2 per cent of the eggs are infertile and another 3 per cent contain dead chicks. Normally, the female rears one brood, but like many birds the ruffed grouse frequently renests (19) if frustrated in the first attempt. The clutch of eggs is likely to be smaller in the second attempt at nesting.

Rearing of Young. The newly hatched chicks soon leave the nest, guided by the mother bird, under whose care and tutelage they remain for several weeks. At first the young chicks are dependent upon the mother to help them secure food. She also broods them at night and during inclement weather. The brood continues its gregarious existence at least until fall and often through the winter, although during most of this period the juvenile birds are able to fend for themselves.

Studholme (37) working in Pennsylvania found that the average of 98 brood counts was 5.8 birds. In New Hampshire 52 brood observations showed an average of 6.0 chicks in June, 3.7 in July, and only 2.3 in early August (25). After 2 or 3 weeks, the chicks are partially feathered and short flights are possible. When the brood is menaced by the intrusion of an enemy, the mother feigns a crippled condition, calls repeatedly, and awkwardly flutters about always in sight but just out of reach, while the chicks "freeze" in their tracks or scurry to cover.

Both composition of cover and aspect of slope seem to play an important role in the suitability of range for young grouse.

In New Hampshire it was found that of 52 brood observations only 5 per cent were made on northeast or northwest slopes and none were made on slopes facing north. Seventy-five per cent of the broods were found in stands containing conifers. Among ground-cover species the grasses seemed to be most commonly associated with grouse broods. Wild strawberry, low-bush blueberry, running blackberry, Canada mayflower, checkerberry, bracken fern, hay-scented ferns, meadowsweet, and juniper were all commonly used by the broods. There were indications that the chicks fed on the aphids which dropped from gray birch and possibly elder.

Movements. Information on the extent of grouse movements is so limited that this subject must be treated in a somewhat cursory manner. Daily movements concerned with the normal routine of feeding and roosting are probably confined to distances of less than 1/4 mile. Birds disturbed frequently and provoked to flight to escape enemies presumably may travel farther. In parts of the range where man is a constant disquieting factor, a frightened bird may fly 1/3 mile, while flight under otherwise similar conditions in remote, less populous sections may cover little more than the distance to the lower limbs of an adjacent tree. Under circumstances where disturbing influences are relatively insignificant, birds may

be flushed day after day in the same locality and often roost in the same trees for considerable periods.

Seasonal movements, though more extensive than daily movements, are not likely to exceed a mile. Marked birds have been seen 1,000 feet from the banding station (19), and Fisher (21) found nests up to 1,200 feet from the nearest drumming log. The area of range used by 27 broods studied by Fisher (21) in central Michigan averaged 40 acres in extent.

Long flights often exceeding a mile sometimes occur, however. Occasionally grouse embark upon "crazy flights," so-called, notable principally for the erratic behavior of the birds and the strange places in which they appear. Birds on such flights have been seen in the center of large cities several miles from the nearest grouse cover, and records of birds having flown through windows into buildings are numerous. This has been known to happen both in the fall and spring. Little is known of this phenomenon except that it occurs. Some investigators believe it to be primarily a characteristic of juvenile birds, while Gross (*41 g.r.*) suggests that it may be a pathological condition. Edminster (18) says that the "crazy flight" is a natural phenomenon related to the breaking up of the family group in the fall.

Taverner (38) states that ruffed grouse are found on Grand Manan Island, a flight of 6 miles over open water and that the only place birds could come from is the mainland. He believes that 10 miles over open water is about the limit of flight for ruffed grouse.

Cover Requirements. Forests, in one form or another, are the typical habitat of the ruffed grouse, and rarely are these birds found outside its environs. Cover requirements are seasonal in character, and no single cover type satisfies all needs for the entire year. In general, grouse tend to frequent the more densely forested areas during winter and the spring nesting season and more open brushy types during other seasons.

For winter tenancy a mixed stand of hardwoods and evergreens forms an excellent habitat. The conifers, which need not comprise a large part of the stand, provide roosting sites and protect the birds against predators and the rigors of winter weather.

Turberville (40) has shown that winter wind movements are much less through coniferous crowns than through those of hardwoods and that temperature changes are slower and not so extreme in the conifers. The hardwoods supply food materials in the form of browse, which during the winter provide the major part of the grouse diet. The ideal winter cover is one that contains a sufficient number of conifers to satisfy roosting and shelter requirements and an abundance of favored food species like aspens, the poplars, birches, and cherries. New Hampshire studies showed that of 51 birds observed during winter 28 were on east and south slopes while only

6 were on those facing north and west. Seventy-eight per cent of the grouse under observation were found in stands containing conifers, with a seeming preference being shown for trees of smaller diameters. Roosting at this season is not restricted entirely to trees, although the previous comments may perhaps have implied that this is true. In fact, tree roosts appear to be a second choice. During the winter grouse frequently bury themselves in loose snow, particularly when winds are high, if it is present in sufficient depth. This they do by digging in or diving in from flight. During unfavorable weather they may remain in this "snug harbor" a day or even longer before emerging. Ledges sheltered from cold winds are also used for roosting.

Breeding cover, which includes drumming cover for the males and nesting cover for the females, has already been discussed.

Summer cover for young broods and molting adults is likely to be less heavily forested than the range occupied in winter but lacks none of its protective quality. In fact, cover suitable for late summer is likely to be extremely dense, at least in part, for neither juvenile birds nor the adults, which molt from mid-July to September, are able to fly well at this time. Hence they must rely upon thick vegetation for escape and concealment. Open glades supporting a growth of ferns and shrubs, brushland containing tangles of brambles and other low-growing plants, young stands of hardwoods, and alders along swamp margins, streams, and lake borders are typical haunts at this season. King (28) lists dense northern white cedar, spruce, and balsam fir about swamps as other favorite summer-cover types. It is very likely that the reasons grouse prefer conditions of the sort just described are as much concerned with their food habits as cover needs. Most of these vegetative types produce fleshy fruits and contain insects in abundance; both of these items are important constituents of the summer diet. The cover-type factor is of particular importance from the viewpoint of young grouse, which feed heavily upon insects during the summer months.

During the fall grouse are usually found on higher ground than in summer if the topography is uneven and also in more open types. Young and old are now capable of strong flight and therefore depend less upon the protection of dense cover than during the summer. During the fall season they commonly frequent sites that produce autumn fruits abundantly, particularly abandoned farm lands and openings in the forest where oaks, apple trees, hawthorn, grape, viburnums, and dogwoods abound. Although such locations often provide relatively little protection, more suitable cover near at hand affords a safe retreat. Rarely do birds venture far from the security of adjacent woodland.

The following combination of cover types represents, according to Edminster (14), ideal grouse range for year-round use in New York.

Composition of cover types	Per cent of total area	Seasonal use
Hardwoods 4 to 8 in. in diameter with an intermixture of hemlock or spruce.	30	Nesting ground
Logging slash, thickets of brambles, etc.	10	Summer feeding grounds
Brushy lands with hawthorn, viburnum, etc. .	20	Fall feeding ground
Mixed woodland of hardwoods and conifers, especially hemlock .	30	Winter shelter and feeding ground
Open land.	10	All-year use

The cover requirements of the ruffed grouse illustrate again the often-repeated concept that diversification of cover is essential to the production of wildlife crops in satisfactory numbers. Grouse, like so many other game animals, thrive only where a variety of cover occurs. The original forest in its unbroken state was probably less conducive to grouse production than the cutover woodlands of today. Maximum productivity, at least in the East, was probably attained within a few years after farming operations ceased, when abandoned farms were reverting to woodland. During that period, cover in a variety of forms and an abundance of fruiting plants provided ideal conditions.

Food. The ruffed grouse is an omnivorous feeder; it consumes animal matter, however, in relatively small quantities, except during the period of early juvenile development. Its diversified feeding habits are well illustrated by Judd's analysis of 208 stomachs taken at all seasons, the contents of which were as follows: fruits, 28.3 per cent; mast and miscellaneous seeds, 11.8 per cent; browse and miscellaneous vegetable materials, 49.0 per cent; and insects, 10.9 per cent (*58 g.r.*). For a comparative picture of the feeding habits of the ruffed and several other grouse consult Table 49 in Chap. X, Prairie Chickens, Sharptails, and Sage Grouse.

With regard to the vegetable food it eats, the grouse is distinctly an opportunist in the sense that it makes the most of whatever food materials are available. In spring, when vegetative growth has just begun, the food consists mainly of tender green shoots and miscellaneous seeds. The summer fare contains insects, seeds, and early-ripened fruits such as raspberries, blackberries, blueberries, and bunchberries. Seeds; late-ripened fruits like apple, hawthorn, greenbrier, viburnums, and dogwoods; and the mast of nut-bearing plants, mostly acorns and beechnuts, comprise the fall foods. Winter food is composed principally of hardwood browse in the form of buds, catkins, bark, and twigs, although some herbaceous materials are taken such as checkerberry (*Gaultheria procumbens*) and

Maianthemum canadense. Fruits and mast are probably preferred, but these materials are rarely available in quantity at this season. The seasonal character of the grouse diet is illustrated in the following table based on an analysis of 411 stomachs of adults collected in New York.

TABLE 53. VEGETABLE FOODS OF GROUSE IN NEW YORK ARRANGED BY SEASONS IN ORDER OF IMPORTANCE (4)

Spring	Summer	Autumn	Winter
Birches	Sedges and grasses	Sedges and grasses	Cherries
Aspen and poplar	Blackberries and raspberries	Cherries	Hop hornbeam
Cherries	Cherries	Hawthorns	Birches
Sedges and grasses	Partridgeberry	Blackberries and raspberries	Hawthorns
Sumacs	Strawberry	Partridgeberry	Sumacs
Hawthorns	Aspen and poplar	Dogwoods	Partridgeberry
Partridgeberry	Violets	Sumacs	Canada Mayflower
Canada Mayflower	Dogwoods	Canada Mayflower	Strawberry
Ferns	Hawthorns	Hop hornbeam	Maples
Hop hornbeam	Snapdragons	Birches	Aspen and poplar *

* The relatively unimportant position of these materials is not explained in the original references. Analyses of winter diet usually place these materials near the top of the list whenever they are available in quantity

It was found in New Hampshire that the wild strawberry was by far the most important food between June 14 and July 14. Then sedges became the most important until about Aug. 1. From then until Oct. 1, raspberries and blackberries ranked first, followed by slugs (*Limax* spp.), insects, blueberries, and a large number of other fruits and leaves. October found apple fruit by far the most important food, followed by thorn-apple fruit and apple leaves. In November grapes and apples were first choice, closely followed by sheep sorrel (29).

Winter foods have been studied rather intensively, principally by the U.S. Biological Survey, and published data present a relatively clear picture of feeding habits at this season. In none of these analyses did animal matter occur in appreciable amounts, generally composing less than 1 per cent of the total stomach contents. Tables 54, 55, and 56 summarize the data of several studies and depict regional preferences.

Herbaceous materials generally represent between one-third to one-fifth of the fall and winter food diet. Kuhn (30) found that this element amounted to 33 per cent of the total; Nelson and his coworkers (33) found it to be 31 per cent; and the data summarized in Table 55 shows a variation from 9 to 31 per cent. This class of foods contains a large number of plants, of which sheep sorrel appears to be a favorite. Others of importance listed by various authors include pussytoes, ferns, asters, foamflower, selfheal,

TABLE 54. ORIGIN OF THE PRINCIPAL WINTER FOODS * OF RUFFED GROUSE AS SHOWN BY CERTAIN STUDIES BASED ON ANALYSIS OF STOMACH CONTENTS AND EXPRESSED IN PERCENTAGE OF THE TOTAL BY VOLUME

Northeast (3), Dec.–Mar. (111 stomachs)		New York (27), Dec.–Mar. (80 stomachs)		Pennsylvania (30), Oct. 31–Nov. 12 (230 crops)		Virginia and West Virginia (33), Nov. and Dec. (184 crops and 107 gizzards)	
Plants	Per cent	Plants	Per cent	Plants	Per cent	Plants	Per cent
Apple	14	Hop hornbeam	15	Cherry	12	Greenbrier (fruit)	16
Cherry	10	Poplar	12	Sheep sorrel	11	Oak (acorns)	11
Poplar	9	Birch	12	Oak (acorns)	9	Grape (fruit)	9
Birch	6	Cherry	9	Poplar	6	Mountain laurel	8
Oak (acorns)	5	Apple	6	Greenbrier (fruit)	5	Wintergreen	6
Sumac (fruit)	4	Blue beech	4	Apple	5	Sheep sorrel	5
Blueberry	3	Wood fern	4	Foamflower	5	Blueberry and huckleberry	4
Rose (fruit)	1	Sumac (fruit)	3	Grape (fruit)	4	Rose (fruit)	4
		Wintergreen	3	Shadbush	4	Ferns	4
		Strawberry	2	Barren strawberry	4	Asters	3
		Barren strawberry	1	Birch	3	Viburnum (fruit)	3
				Hop hornbeam	3	Pussytoes	2
Others	48	Others	29	Others	29	Others	25

* Chiefly browse (buds, twigs, leaves, and catkins) except where noted.

avena, grasses, clover, goldenrod, cinquefoil, strawberry, and barren strawberry.

It is perhaps worth noting that certain foods, though unimportant if judged in terms of their volume occurrence, appear in a consistently high proportion in grouse stomachs. Notable among these are partridgeberry, dogwoods (especially bunchberry), sumacs, and rose hips. It seems evident that such materials are attractive, but whether the small quantity consumed indicates an appetite easily satisfied or an insufficient supply of materials is a debatable question. Another fact deserving mention, because none of the data cited points to it, is the highly desirable nature of beechnuts as a winter food. Beech mast appears to be a preferred food, consumed in large quantities when available (30). Unfortunately, heavy crops of this seed are borne only at irregular intervals of several years, and much of this is consumed by squirrels.

TABLE 55. THE PRINCIPAL FALL AND WINTER FOODS (OCTOBER–MARCH) TAKEN BY RUFFED GROUSE AS SHOWN BY STOMACH ANALYSES (*56 g.r.*)

	Average per cent of total stomach contents *									
	Maine	N H	Vt	Mass	R I	Conn	N Y	Pa.	Mich	Wis.
Plant materials:										
Dogwoods	2 0†	1 8†	. ...	5 5†	2.1†	5 2†	1 6†	10.1†	1 1	7.1†
Hawthorn.	6 9†	7.2†	11.3†	10 0†	1 0†	3 8†	8 6†	1 4	.....	3.3†
Poplars	6 0	2 1	10.5†	1 2	.....	1 8	4 6	1 6	22 5†	14 8†
Oaks	5 6	4 8†	3 9	12 7†	45 5†	13.2†	1 1	5.6	.....	4 0
Grapes..............	.....	2 5	3 6	5 9	8.4†	28 2†	8 4	7.7	.....	4 1
Birches	9 0†	2 8	8 0†	1 9	... .	.....	10 0†	3 1	22 2†	
Hazel	1 2	1 3	2 6	1 9	.....	.....	1 6	.....	14 8†	4 6†
Cherries...	2 5	9 1†	11.0†	1 7	.....	2.3	4 6	.....	2 6†	
Sumacs	2 1	3 8†	.....	4 5	... .	3 4†	2 3†	6 4†	.....	2 9
Apples	8 1†	12 0†	5 1†	5 6	.....	2 1	3 3			
Blueberries	3 3†	4 5†	1 2	2 5	3.1†	.....	1 1			
Viburnums	1 5	4 6	.....	3 8	.....	4 3	1 2	1.3		
Wintergreen	1.0	1 6	.....	......	1 2	1.0	1 5		†	
Partridgeberry.......	†	1 9†	.....	3.4†	†	1 3†	2 0†	1.0†		
Roses	2 3†	......	.....	1 5†	†	1 4	1 1	.....	.....	.1†
Hop hornbeam.......	.....	1 1	.....	......	.....	....	10 4	5 2	.....	22 1†
Brambles	.....	5.5†	2 0†	1.6	2.4†	†				
Beech	6 0	......	3.0	......	.....	.....	......	34.2†		
Bayberry and gale...	.....	......	.....	1 2	4 3†	4.5				
Other woody and herbaceous plants . .	11 5	13 4	4.8	13.1	23 0	13 5	14.6	7.4	15.8	5.0
Percentage of diet taken from:										
Above woody and herbaceous plants	69 0	80.0	67 0	78 0	91.0	86.0	78 0	85.0	79.0	69.0
Other herbaceous plants	31.0	20.0	33.0	22.0	9.0	14.0	22.0	15.0	21.0	31.0
Number of stomachs analyzed	72	175	26	234	57	80	218	63	10	26

* Includes only those cases where the listed food formed at least 1 per cent of the contents.
† Foods occurring in at least 20 per cent of the stomachs.

TABLE 56. THE FOUR MOST IMPORTANT HERBACEOUS NEW ENGLAND WINTER GROUSE FOODS ARRANGED IN ORDER OF DECREASING VOLUME TAKEN (26)

Maine	New Hampshire	Vermont	Massachusetts	Connecticut	Rhode Island
Canada Mayflower	Sorrel	Clover	Canada Mayflower	Skunk cabbage	Canada Mayflower
Fern (*Dryopteris*)	Clover	Canada Mayflower	Clover	Sorrel	Skunk cabbage
Mayflower (*Epigaea*)	Canada Mayflower	Miterwort (*Mitella*)	Shinleaf (*Pyrola*)	Sedge (*Carex*)	Rattlesnake fern
Wood sorrel	False Solomon's seal	Wood sorrel	Fern (*Dryopteris*)	Canada Mayflower	Strawberry
Stomachs analyzed, 72	229	26	234	123	57

The ruffed grouse sometimes does considerable damage by budding apple trees in orchards adjoining woodlands. This winter feeding removes both leaf and flower buds from the short, lateral spurs, thus reducing both the amount of fruit setting and the leaf area capable of developing the fruit (36). In 1923–1924 the New Hampshire Fish and Game Department paid about $25,000 for damage to orchards by grouse budding (5).

The food of juvenile grouse contains a high proportion of animal matter, mostly insects. The proportion is greatest early in the summer and gradually decreases until by fall the juvenile diet conforms closely to that of adult birds. After the bird's first season, animal matter never assumes its earlier importance. Darrow's (12) work on the food habits of grouse in New York illustrates this change of diet and the declining importance of animal matter as the summer advances. In June this element of the young chick's food comprised approximately 58 per cent of the total stomach contents; it was 12 per cent in July and only 4 per cent in August. The favored vegetable materials during this period of high animal-material consumption are fruits of the genus *Rubus*, strawberries, and the seeds of the genus *Carex*.

Water and Grit. Like many other birds, the grouse is able to satisfy its water requirements without resort to water in the free state. Dew and succulent foods such as fruits and green shoots satisfy moisture needs under normal circumstances. However, the grouse range is usually well supplied with springs, streams, and ponds, and during the winter water in the form of snow is almost always available. Probably at no time do ruffed grouse suffer seriously from lack of moisture.

Grinding agents in the form of gravel, chitinous parts of insects, and hard-coated seeds are an essential part of the diet of grouse. During the winter, when grit is least available, it is likely to be most needed, for the staple foods consumed at that season are not easily digested. At this time when gravel is often scarce—even though possibly obtainable on ledges, upturned tree roots, and similar sites—it may become necessary for birds to rely largely upon seeds with tough integuments, such as rose, smilax, dogwood, sumac, and black gum, for grinding action. Beer and Tidyman (*16 g.r.*) found that hard seeds such as those of the rose, snowberry, *Smilacina*, cherry, and hawthorn increased in volume in ruffed grouse stomachs as grit decreased. However, despite the seeming scarcity of available gravel, the gizzards of the 80 birds from New York examined by Kelso (27) contained surprisingly large amounts of it; this material comprised 8.8, 9.8, 6.2, and 4.8 per cent of the total gizzard contents for the 4 months of December through March, respectively. On eastern ranges hawthorn seeds appear to be used as a grinding agent more than any other seed.

Population Density. The ruffed grouse is one of a group of game animals among which populations are subject to peculiar cyclic fluctuations, as yet not fully understood, in which a period of slowly increasing numbers and one of rapid decimation follow each other at recurrent intervals. While the subject of cycles is discussed in another chapter, the grouse is so typically cyclic that it seems appropriate to list here some of the known facts concerning its relationship to this natural phenomenon:

1. Cyclic fluctuation occurred prior to the advent of white settlers.
2. The cyclic interval varies from 8 to 13.5 years and between 10 and 12 years (*66 g.r.*).
3. Decimation is greatest among juvenile birds and during summer (*40 g.r.*, 11). Older birds, especially those 4, 5, and 6 years old, seem best fitted to survive (28).
4. Peak populations occurred in various parts of the Eastern grouse range during the period 1933–1935.
5. Of weather conditions in relation to decline of ruffed grouse populations Edminster (18) has the following to say:

> Every time severe February–March snow conditions and very low temperatures followed by a very cold June occurred in two successive years, a grouse decline (in New York) followed, and every time there was an important grouse decline, these weather conditions had prevailed.
>
> It . . . [see above] is far from a perfect record of cause and effect but is so impressive that the importance of climatic factors in relation to grouse population trends can hardly be discounted lightly. Weather conditions play a big part in grouse fluctuations both great and small.

Losses as a result of the abnormal weather conditions described by Edminster may be due to a variety of effects. For New York state Edminster has the following to say:

> The high losses that occur during late winter deep snows and low temperatures are brought about by predation induced by the weather. The high losses to young birds in June accompanying low temperatures and heavy rains are caused by either disease or exposure or a combination. I can't separate them. If disease organisms are involved, they, in turn, are certainly induced by the effect on the body of chilling and soaking.

Other agents may operate to bring about losses on other parts of the range, but this in no way nullifies the hypothesis of weather as the basic cause of grouse losses.[1]

The data cited in Table 58 represent better than average conditions

[1] Information given to the author by letter, Sept. 11, 1947.

TABLE 57. THE POPULATION OF RUFFED GROUSE ON 4 SQUARE MILES OF RANGE IN MINNESOTA AS SHOWN BY SUCCESSIVE CENSUSES (31)

Date of census	Population	Gain or loss
April, 1935	199	
November, 1935	75	−124
January, 1936	36	− 39
April, 1936	32	− 4
October, 1936	81	+ 49
April, 1937	25	− 56
March, 1938	60	+ 35

for the most part. The densities recorded by King in Minnesota mark what he believes to be the maximum overwinter carrying capacity for the very best range. For spring populations a density of one bird for 4 acres is about the limit.

TABLE 58. SUMMARY OF STUDIES OF THE POPULATION DENSITY OF RUFFED GROUSE RANGE IN MINNESOTA, NEW YORK, AND MICHIGAN

State and investigator	Year	Study area, acres	Acres per bird	
			Spring	Fall
Minnesota (28)	1931	1,800	?	3.4
	1932		4.1	2.4
	1933		4.0	1.8
	1934		4.0	?
New York (15)	1930	2,304	37	16
	1931		18	8
	1932		12	5
	1933		9	8
	1934		12	5
	1935		10	8
	1936		15	8
	1937		21	9
Michigan (21)	1932	2,520	?	4.7
	1933		15.2	6.6
	1934		229.0	8.9
	1935		168.0	21.2
	1936		60.0	15.7
	1932	2,161	?	7.3
	1933	2,574	10.9	4.8
	1932	2,044	?	2.8
	1935		25.6	5.7

TABLE 59. POPULATION DENSITY OF RUFFED GROUSE ON CERTAIN NATIONAL FORESTS IN THE GREAT LAKES REGION BASED ON REPRESENTATIVE SAMPLES VARYING FROM 2 TO 16 SECTIONS *

State and forest	Year	Acres per bird		
		Spring	Fall	
			Before hunting	After hunting
Michigan:				
Huron	1935		10	16
	1936	27	14	
	1937	38	14	
	1938	23	16	23
Manistee	1935	40	.	6
	1936	34	16	29
	1937	32	14	
	1938	43	14	
Upper Michigan	1935	..	.	26
	1936	40	23	
	1937	53	21	
	1938	46	8	11
Ottawa	1936	36	..	36
	1937	24	31	
	1938	10	..	17
consin:				
Chequamegon	1935	16	9	16
	1936	38	17	
	1937	36	13	
Nicolet	1935	34	..	29
	1936	..	..	16
	1937	30	7	
Minnesota:				
Chippewa	1935	15	9	12
	1936	..	36	
	1937	..	13	
	1938	20	11	
Superior	1935	23	11	
	1936	28	20	
	1937	34	15	
	1938	36	10	

* Unpublished information made available to the author by the U S. Forest Service, Division of Recreation, Lands, Wildlife, and Range Management, Region 9, Milwaukee, Wis.

MORTALITY

The typical life equation of the ruffed grouse in New York is represented by Edminster (15) as follows:

Factors	When the population is on the upgrade	When the population is at peak of cycle
Disposition of 18 adult birds surviving from previous season from one breeding season through the next one:		
Die from natural causes during period of 1 year.	4	6
Killed by hunters during fall hunting season	3	3
Survive to next season	11	9
Disposition of 100 potential birds (eggs produced by the 18 surviving adults) from one breeding season to the beginning of the next:		
Eggs infertile	2	2
Die in the egg	3	3
Destroyed in the egg	37	37
Die from natural causes while immature birds	31	36
Die from natural causes while mature birds	7	9
Killed by hunters	5	4
Survive to the next season	15	9
Total surviving breeding stock	26	18

The following record of mortality from all causes on a tract of about 2,000 acres in New York is perhaps a fair example of Eastern conditions (17):

	1931	1932
Nest mortality, per cent	51	72
Brood mortality (birds up to 3 months old), per cent	67	55
Adult mortality (birds 3 months of age and older), per cent	14.5	21
Population density, Sept. 1, acres per bird	10.2	5.5

Mortality before Hatching. Because the nest of the grouse is built on the ground, it is subject to the usual high mortality typical of nearly all ground-nesting birds. However, this factor appears to vary considerably from year to year as well as among localities. Moreover, it seems likely that the proportion of successful nests is higher among grouse than certain other game birds, particularly those like the bobwhite and pheasant, which place their nests in fields and other locations where the activities of man are an ever-present danger. A state-wide check of nests in New York showed man responsible for but 12 per cent of the reported nest failures (10).

According to Bump (6, 7), nesting losses in New York from 1930 to 1935 averaged about 40 per cent for the 1,030 nests examined. The fox, weasel, skunk, and crow were the most important agents of destruction. In sharp contrast is King's (28) report of several hundred nests observed in Minne-

sota, where only about 3 per cent were wholly destroyed. An additional loss, amounting to approximately 5 per cent of all the eggs under observation, occurred in 30 per cent of the nests. This loss was attributable principally to squirrels and chipmunks. The former usually destroyed and ate several eggs if they contained well-developed embryos; the latter simply hid the eggs.

Other animals known to destroy grouse nests include raccoons, opossum, bobcats, dogs, domestic cats, snakes, owls, and hawks.

Losses Due to the Elements. Mortality among juvenile grouse, especially during the first few weeks when the chicks are easily injured, is often high and usually exceeds all other causes of loss. King (28) believes that juvenile mortality (he includes nesting losses in this category) is normally at least 75 per cent and sometimes even larger. If this figure is corrected by eliminating nesting losses (eggs that are infertile or contain dead embryos), mortality among chicks and immature birds is still considerably more than 50 per cent. Edminster's (15) data for New York indicate a similar decimation. Bump (10) reports that broods of young grouse kept in open, poorly sheltered pens in New York suffered losses up to 80 per cent. Just what part of such juvenile mortality can be attributed to the elements is a debatable question. King (28) found that young chicks frequently fell into holes from which they were unable to extricate themselves and so were lost or drowned or died of exposure. This investigator was unable to find evidence of any significant predatory loss or disease, again suggesting that the chicks succumbed to the vicissitudes of the weather.

Mortality among mature birds is heaviest during the winter. However, despite the rigorous climate in which the ruffed grouse lives, it exhibits remarkable hardiness and is well adapted to its winter environment. Roosting in deep snow or dense conifers, it is sheltered against cold and snow; and by virtue of its ability to feed upon browse, it rarely lacks food. Perhaps its worst atmospheric enemy is sleet, which coats twigs with ice, thereby rendering food supplies inaccessible. Sleet likewise may trap the roosting birds beneath the snow.

Losses Caused by Predators. This subject has received serious study in only a few sections, and published data are sparse. Predator losses among adult grouse on several experimental areas in New York varied from 13 to 45 per cent (10). The culprits responsible for the bulk of the predation were hawks, owls, and foxes, accounting among them for at least three-quarters of all the losses and probably more, for most of the remaining 25 per cent of the losses was unidentified. The great horned owl, the Cooper's hawk, and the red fox were the three most destructive species.

In Minnesota King (28) estimated the normal winter loss to be about

20 per cent, due to a variety of causes including diseases, accidents, weather, and predators.

Although the data already referred to suggest that foxes are serious predators of grouse, Hamilton's (23) work with the red fox belies this conclusion. Of 273 stomachs taken during the fall and winter in New York and New England, only 4 contained evidence of ruffed grouse remains. Droppings collected during the late summer and fall in Massachusetts present substantially the same picture (24). Of some 82 gray fox stomachs collected during the winter in Virginia and studied by Nelson (34), grouse remains occurred in only one. Dearborn (13) stated that on the average the individual fox in Michigan ate not more than two grouse per year. A similar somewhat incompatible situation appears to hold for the great horned owl. Studies of ruffed grouse point to this bird as being an important cause of mortality (21), but examinations of pellets and stomachs offer contradictory evidence. Of 726 pellets collected in Wisconsin, less than 2 per cent contained parts of ruffed grouse, while only 4 out of 492 stomachs taken in Pennsylvania from November through May contained grouse remains (*63 g.r.*).

Dearborn (13) found no evidence of grouse in feces of wildcats collected in Michigan, even though grouse were abundant in the vicinity. Only when rabbits and mice are scarce do wildcats tend to prey consistently upon ruffed grouse. The theory that predation is closely allied to the carrying capacity of a given range and the population it supports appears to apply to the grouse-predator relationship. King (28) found in Minnesota that the April population on an experimental tract, where density was at its maximum for the range, tended to remain more or less constant, regardless of the population during the preceding fall. A successful breeding season merely produced an excess population, which succumbed to predation. Errington (20) reported a similar correlation in Wisconsin.

Losses Due to Hunting. Losses due to hunting vary with the density of population and the period within the population cycle. When the cycle is on the upgrade and conditions are highly favorable, the kill is likely to be high in numbers but of less significance from the viewpoint of seriously reducing the breeding stock than a smaller kill at the low point in the population cycle. At the low point a relatively small bag may account for a large part of the existing population and may therefore seriously check the progress of recovery of the grouse population. A closed season is the best guarantee against overshooting when the numbers of birds are low.

A fair cross section of typical hunting conditions under Lake states conditions at the peak of the population cycle is shown by the following record of the hunting take for three tracts on the Superior National Forest in Minnesota (39):

TABLE 60. RESULTS OF HUNTING ON RUFFED GROUSE POPULATIONS IN THREE TYPICAL GROUSE AREAS IN THE LAKE STATES (39)

Tract	Area, acres	Grouse population		Actual hunting take	Per cent of total population before hunting	Acres per bird killed	Man-hours to kill 1 bird
		Before hunting	After hunting				
A	1,280	340	312	32	9	40	2
B	2,560	176	112	64	36	40	2
C	2,560	220	104	84	38	30	1
Total	6,400	736	528	180	24	36	1.5

Bump's (10) estimate of the loss due to hunters in New York was about 15 per cent. Fisher (21) states that the yearly kill by hunters on sample areas in Michigan are of minor importance as compared with the number that die from other causes. The following tables (Tables 61 and 62) formed the basis for Fisher's conclusion:

TABLE 61. RECORD OF HUNTING TAKE ON RUFFED GROUSE RANGE IN MICHIGAN (21)

Year	Upper Peninsula		Lower Peninsula	
	Birds flushed per gun-hour	Birds bagged per gun-hour	Birds flushed per gun-hour	Birds bagged per gun-hour
1930	...	...	2.4	0.29
1931	..	....	3.0	0.37
1932	2.8	0.46	2.5	0.32
1933	1.2	0.37	1.6	0.19
1934	1.1	0.33	2.0	0.30
1935	1.0	0.24	1.3	0.21

TABLE 62. COMPARISON OF THE HUNTING TAKE ON RUFFED GROUSE AREAS OF EQUAL SIZE IN THE UPPER AND LOWER PENINSULA OF MICHIGAN (21)

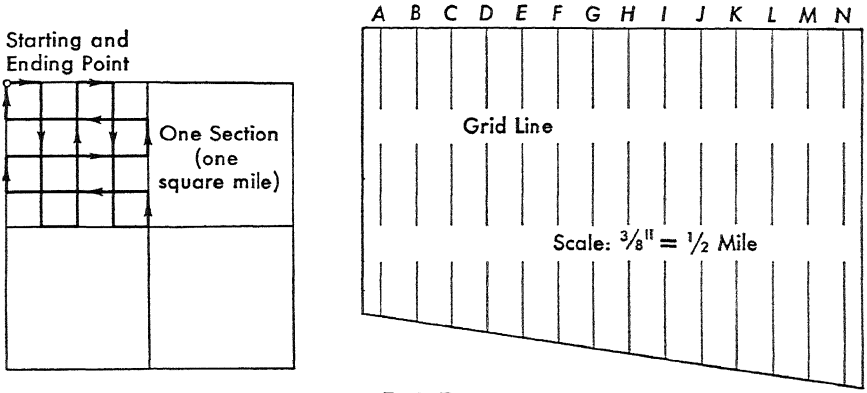
Tract	Date	No. of hunters	Total hunting hours	No. of birds seen	No. of birds bagged	Per cent bagged *
A	1935	192	1,005	1,098	190	17
	1936	280	1,439	2,407	345	14
B	1935	164	906	347	43	12
	1936	231	1,014	366	82	22

* It should be noted that the figures on percentage of birds bagged as given by Fisher indicate the proportion of the birds flushed that were shot rather than the percentage of the total population.

Phillips (35) stated that it is unsafe to take more than two birds per nesting pair on the average and none at all during the low of the population cycle.

MANAGEMENT

Census Methods. The *grid method*, devised by King (28), is perhaps the most reliable. It is based on the theory of sampling and resembles in many respects the strip-method technique used by foresters to estimate standing timber. In taking the census the enumerator proceeds on foot back and forth across the tract along a series of straight parallel lines established at uniform intervals (see Fig. 11·2). As each grouse is flushed, the estimator measures and records its flushing distance (see Fig. 11 2), this being the shortest distance between the observer and the point where the bird began flight. Two other facts are essential to the final computations: (1) the total area of the tract, which is usually known in advance, and (2) the length of each grid line, which is measured as the lines are established, either by the enumerator as he proceeds with the census or at some earlier time. Distances may be measured in any convenient unit, such as feet, yards, or chains, and area is computed in square feet, square yards, square chains, or acres.



Basic Data

1. Area of tract, 5,040 acres
2. Combined length of grid lines A to N, 29¼ miles (154,440 feet)
3. Number of grouse flushed, 45
4. Aggregate of flushing distances, 2,250 feet

Computations

5. Average flushing distance, $\frac{2{,}250}{45} = 50$ feet
6. Area of sample, $2 \times 50 \times 154,440$ square feet, or 354.5 acres (15,440,000 ÷ 43,560)
7. Total population, $\frac{5040.}{354.5} \times 45 = 640$
8. Acres per bird, 5,040 ÷ 640 = 7.9

FIG. 11·2. The grid-census method. Location of grid lines and method of computation.

From these data, the estimated total population is calculated by the following formulae:

$$\text{Population of tract} = \frac{\text{area of tract}}{\text{area of sample}} \times \text{population of sample}$$

$$\text{Area of sample (see Fig. 11·3)} = \text{average flushing distance of all birds} \times 2 \times \text{total length of all grid lines}$$

The interval between grid lines should be about 20 chains (¼ mile). If a larger interval is used, the sample becomes correspondingly smaller and less reliable. If the interval is decreased, the probability is strong that flushed birds may be encountered again on an adjacent line. Even at the suggested interval, duplication is not wholly unavoidable, and a smaller interval simply aggravates this condition. Accuracy depends not only upon the degree of sampling but also upon the size of the sample. King believes that results are likely to be misrepresentative unless the census area contains at least 4 square miles and the grid lines cover no less than 30 miles. He also places little reliance on the accuracy of any census with less than a minimum of 40 birds flushed.

Late autumn is the best time for this type of census, because visibility is greatest at that season. Ordinarily snow is not present, although snow is not a handicap except that it makes foot travel more difficult.

When the census is taken but once or at infrequent intervals, the grid lines are usually established by the enumerator at the time of the census. Using a hand compass, he lays out the course as he goes and paces the distance if he operates alone. Two men are needed if the course is measured with a tape. If the census is to be repeated frequently, it is advisable to establish the grid lines prior to the first census and to mark and maintain them thereafter as a permanent fixture in the program of wildlife management. Bands of bright-colored paint, such as red, orange, or light blue, or colored tags attached to trees with copper nails are suitable for marking. Permanent lines facilitate more rapid work and probably foster greater accuracy, for the enumerator is then able to devote his attention entirely to the census. Otherwise, his mind is always somewhat engrossed in other details such as following the compass and counting the paces.

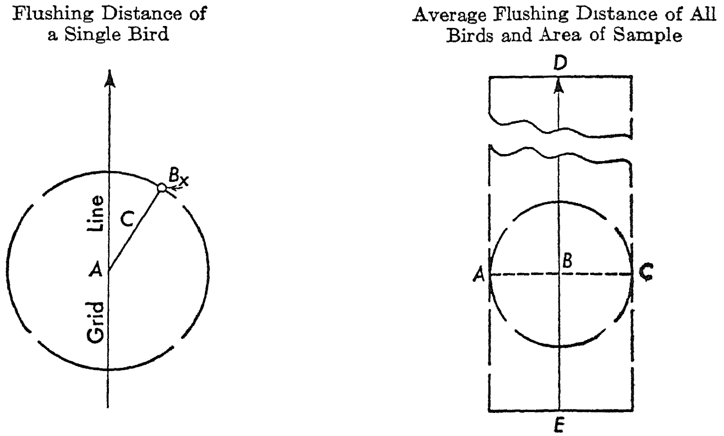
This system of census, as originally devised, was applied to a region subdivided by the rectangular system of land survey. Grid lines were run in two sets of parallel courses at right angles to each other. For the sake of convenience, they were made to follow the ¼-mile survey lines, in both directions, thereby covering 8 miles for each whole section of 640 acres. Four sections worked in this manner provided a suitable sample. Certain precautions need to be observed with the use of King's method of grouse census.

Weather. Do not attempt to census ruffed grouse when there is a strong

wind blowing or when it is raining or snowing. Do not take the census when the air temperature is $-10°F.$ or colder.

Time. Walk the census lines as a continuous process. If a delay is necessary after the census has been started, begin the census again rather than proceed with it after a delay.

Repetition. If census lines run at right angles to each other, there will be some duplication where the lines cross. If the same color phase of ruffed



A—Position of census enumerator when grouse (x) is flushed at *B*.
C—Flushing distance.

AB—Average flushing distance of all birds.
AC—Width of sample (2 × average flushing distance).
DE—Length of sample (combined length of all grid lines).
AC × *DE*—Area of sample.

FIG. 11·3. The grid-census method.

grouse (red phase or gray phase) is noted at a corner at a considerable time interval after a former flush has been made, do not use the second flush in the calculations. If the second flush is a different color phase from the first, it should be used.

The King grid-census method does not give satisfactory results where (1) grouse are scarce, (2) where the topography is such as to cause an altitudinal diversification of the vegetation types, (3) where the preferred seasonal food supplies, particularly fall foods, are grouped in a limited part of the range.

A *count of drumming males* serves as an index of the adult spring breeding population, provided the sex ratio is known. When both these factors have been determined, the combined population of both sexes is quickly computed by a simple proportion. In counting drumming cocks, Graham (22) suggests using a method based on the principle of locating an unknown point by the intersection of compass lines extended from two or more

known points. From several stations established about the tract being censused, the approximate location of each drumming bird is determined by sound and recorded as the compass bearing of a line projected from the station to the apparent site of drumming activity. Later, the bearings from the several stations are plotted on a map, and the points of intersection place the birds and indicate their numbers. Repeated observations conducted several mornings in succession provide a reliable measure of the drumming population.

Graham recommends four to six stations for each quarter section (160 acres). Several observers located one at each of the stations is the easiest and most accurate procedure, but one man working alone can make the rounds in time if stations are easily accessible. If the census is taken by a single observer, he need spend only a few minutes at each station. At the height of the early-morning drumming period, drumming is nearly continuous and the necessary data are quickly obtained. After it becomes light, the birds begin to move about, drum sporadically and not uncommonly from more than one location.

Edminster (18) gives the following type of census for practical purposes. In mid-August and mid-October representative samples of the grouse range are covered thoroughly. The census is conducted during daylight hours from one hour after daylight to an hour before sunset during clear weather. For the early count, the lines traversed should be 25 to 40 feet apart, but for the autumn or October count the lines may be 50 to 75 feet apart. He suggests that during a man-day of 8 hours 50 acres should be covered, and in good grouse range during a period of average abundance two broods should be flushed during that time. With 5 grouse to a brood each 50-acre unit would thus have 10 birds. If only one brood is flushed per each 50 acres, the population is low; if more than two broods are flushed, the population is high.

The final results should be based on the average of several coverages rather than on a single time over. Where the census plot is being used as a sample of a larger area, he suggests the sampling of 100 acres out of each 10,000, or a 1 per cent sample.

Food and Cover Development. The improvement of ruffed grouse range under conditions that prohibit intensive measures for economic or other reasons is best considered as a long-time project closely tied in with the management of forests as a source of timber. Cutting plans and the control of the composition and age classes are governed by considerations both present and future. The development of cover and food supplies for grouse by the manipulation of forest-cutting practices is therefore properly regarded as part of a long-range plan of land management. Since the production of grouse on commercial woodland must be subordinated to the production of timber crops, radical changes in the methods of managing

forest lands are not to be expected purely on the premise that grouse alone are thereby benefited. The best that can be anticipated under such limitations is a forest management plan that recognizes the production of grouse as an allied objective and in its program of forest improvements and regulation of cutting operations encourages such wildlife production by all means compatible with sound forestry practice.

From the viewpoint of producing grouse, the forest that best satisfies their environmental requirements is one containing a mixture of conifers and hardwoods of all ages arranged in numerous well-distributed, even-aged stands, not exceeding in area 600 feet in diameter nor smaller than 100 feet. At the other extreme, representing perhaps the least favorable condition, is the extensive forest of either pure conifers or pure hardwoods largely of one age. Intermediate in desirability is the uneven-aged forest with a stemwise distribution of age classes. Silvicultural practice aimed at developing a forest of the first type is the best program for improving ruffed grouse range by extensive measures. Group selection, clear cutting in small units, and intermediate cuttings that encourage mixed composition are excellent means to this end.

Where more rapid improvement of range is desired and other land uses are not of major importance, more intensive procedures may be adopted (41). The following measures are recommended:

1. *The planting of tolerant conifers like hemlock in the understory of stands composed primarily of hardwoods.* Small groups of considerable density are preferable to single tree or large plantings of an open character. Cover of this sort is suitable for nesting and winter roosting.

2. *The cultural treatment of forest stands to favor the growth of browse plants suitable for winter use, particularly yellow and black birch, hop hornbeam, blue beech, poplars, and the cherries.*

3. *The development and maintenance of food plants already established.* Apple trees in abandoned orchards, hawthorn, dogwoods, viburnums, grape, and similar fruiting plants lend themselves to this treatment and once freed from competing vegetation produce fall foods in abundance. Grape is particularly valuable in this respect. If given abundant light and a girdled or felled tree on which to climb, it grows rapidly and extensively, providing not only food but excellent cover as well. Ground cover may need thinning to favor the species mentioned above.

4. *The planting of clover along woods roads and similar sites where conditions are right for its growth.* An opening of the character recommended below is particularly suitable on which to apply this measure.

5. *The planting and maintenance of fruit-bearing perennials* (see Table 63). On recently abandoned agricultural land, fruiting shrubs and trees may be numerous, but elsewhere they are likely to be poorly represented. Although cutting operations that remove or thin out the overstory tend

TABLE 63. FRUIT-BEARING PERENNIALS USED AS FOOD BY RUFFED GROUSE
The asterisk indicates perennials suitable for planting for erosion control *†

Common name	Scientific name	Eastern U.S.	Western U.S.	Season when available			
				Spring	Summer	Fall	Winter
Manzanita	*Arctostaphylos* spp	..	x	..	x	x	
Bearberry	*Arctostaphylos uva-ursi*	x	x	x	x	x	x
*Black chokeberry	*Aronia melanocarpa*	x	..	x	..	x	x
Spicebush	*Benzoin aestivale*	x	..	..	x	x	x
*Bittersweet	*Celastrus scandens*	x	..	x	..	x	x
*Dogwood	*Cornus* spp.	x	..	..	x	x	
*Filbert	*Corylus americana*	x	..	x	..	x	x
Hawthorn	*Crataegus* spp.	x	x	..	..	x	x
Hawthorn	*C douglasii*	..	x	..	x	x	
Huckleberry	*Gaylussacia* spp.	x	..	..	Late	Early	
Holly	*Ilex opaca*	x	..	x	x	x	x
Black alder	*I. verticillata*	x	..	..	..	x	x
*Apple	*Malus* spp	x	x	..	.	x	x
*Bayberry	*Myrica carolinensis*	x	.	..	x	x	x
*Bessey sand cherry	*Prunus besseyi*	x	.	..	Late	Early	
Cherry and wild plum	*P.* spp.	x	.	..	Late	Early	
*Wild plum	*P. subcordata*	.	x	..	x		
Virginia creeper	*Parthenocissus quinquefolia*	x	x	..	x	x	x
Sumac	*Rhus* spp.	x		Early	Late	x	x
Skunkbush	*R trilobata*		x	Early	Late	x	x
*Rose	*Rosa multiflora*	x	x	x	x	x	x
*Rose	*R. rugosa*	x	x	x	x	x	x
*Rose	*R. wichuraiana*	x	x	x	x	x	x
*Trailing raspberry	*Rubus parvifolius*	x	x	..	x	Early	
Redberry elder	*Sambucus callicarpe*	..	x	..	x	x	
American elder	*S. canadensis*	x	.	..	Late	x	x
Blueberry elder	*S. caerulea*	..	x	..	x	x	
Black elder	*S. melanocarpa*	..	x	..	x		
Red elder	*S. pubens*	x	..	..	x		
Greenbrier	*Smilax* spp.	x	..	..	..	x	x
Carrion flower	*S herbacea*	..	x	..	x		
Mountain ash	*Sorbus* spp.	x	x	..	Late	x	x
*Common snowberry	*Symphoricarpus albus*	x	..	x	.	x	x
*Coralberry	*S. orbiculatus*	x	..	x	.	x	x
Blueberry and whortleberry	*Vaccinium* spp.	x	x	.	x		
Maple-leaved viburnum	*Viburnum acerifolium*	x	..	Early	Late	x	x
Whithe-rod	*V cassinoides*	x	..	.	Late	x	x
*Arrowwood	*V dentatum*	x	..	.	Late	x	x
Oregon	*V. ellipticum*	..	x		x	x	x
*Sheepberry	*V. lentago*	x	x	x	x	x	x
*High-bush cranberry	*V. trilobum*	x	..	Early	..	x	x
Cranberry bush	*V. pauciflorum*	x	x	..	x	x	
*Black haw	*V. prunifolium*	x	..	..	..	x	x
Grape	*Vitis* spp.	x	..	..	..	x	x

† From *Soil Conserv. Serv. Tech. Ser.* 10, Biology No. 9.

to encourage this kind of vegetation, results are not always immediate, nor is the fruit produced always of high quality from a grouse diet standpoint. Planting is the most satisfactory procedure where time and not expense is the controlling factor.

King (28) states that late winter and early spring is the period when the shortage of food is likely to be acute. For use at that season he recom-

mends low-growing shrubs that produce nutritious but relatively unpalatable fruit. Fruit of this character is passed by during the fall for other more attractive materials, which are ordinarily plentiful. During the winter such fruit is covered by snow and in this way escapes consumption until the crucial spring food shortage when it again becomes available as the snow melts.

7. *Reservation of swamp and alder types.* These should be retained to serve as cover for broods during summer.

8. *Reservation or construction of slash piles in bramble thickets, in stands of young hardwoods, and along the margin of older stands for nesting and escape use.*

Predator Control. Predator control should be confined to the great horned owl, the Cooper's hawk, the goshawk, and foxes (red and gray). It is perhaps well at this point to emphasize once again that the evidence against these animals is not altogether conclusive; furthermore, attempts at control have been of doubtful value. In fact, studies in New York strongly suggest that control measures during years near the peak of the grouse population cycle are not likely to be effective (17).

In the experiment referred to, one of two adjacent tracts of approximately 2,000 acres each was subjected to complete predator control, the other to none. Control proved effective in reducing the abundance of horned owls, crows, and weasels but made no significant impression upon other predators. Moreover, its effect upon the grouse population was equally inconclusive. The percentage of mortality on the two tracts showed no decided advantage for the area where control measures were undertaken, except in the matter of nesting losses. During the 2 years covered by the study the increase in population density was more rapid on the area having no control, until at the end of the period, population densities on the two tracts were nearly identical. However, Edminster concluded from this work that predator control is probably effective during years of low grouse abundance when the population cycle is commencing its upswing. Its dubious value in the case just cited is perhaps attributable to the fact that populations on the two areas were so dense and increasing so rapidly that the normal decimating effect of predators was relatively unimportant.

Miscellaneous Management Procedures. *The determination of sex* by external characteristics is not easy or always entirely reliable. The males are generally heavier and larger in over-all dimensions, and the black bar near the end of the tail forms a continuous band extending from one side of the tail to the other in all but about 10 per cent of the cases. This band, though present on the female, is likely not to be continuous (1). G. A. Ammann states that sex of *typical* specimens can be distinguished by the length of the middle tail feathers from the tip to where the quills enter the

flesh at the base of the tail. Females have tail feathers *less* than $5\frac{1}{8}$ inches long, and males have tails *more* than $5\frac{5}{8}$ inches long.[1]

The dark feathers on the fore part of the ruff extend across the breast of the male, but not in that of the female, thus exposing the pinkish brown

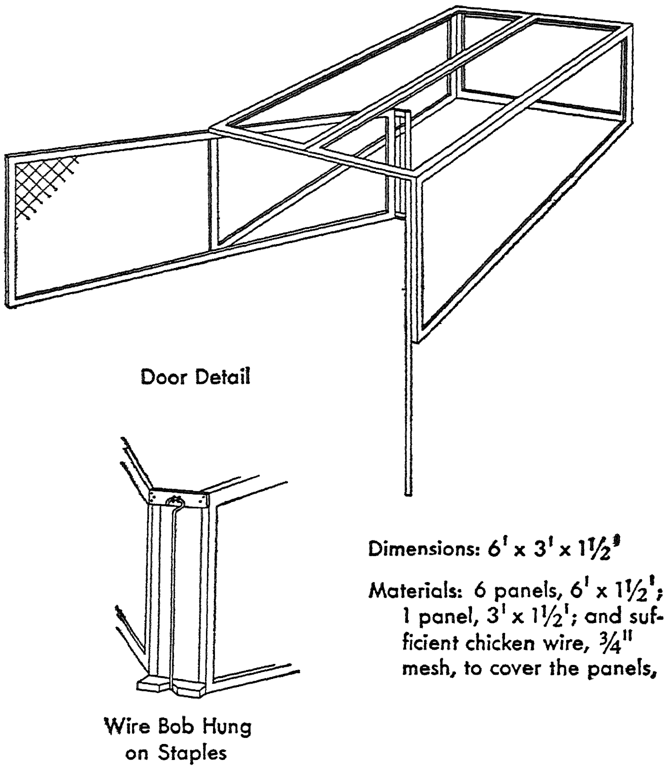


FIG. 11·4. Funnel-type trap for ruffed grouse. The top of the trap is removed until the birds become accustomed to the trap. Where deer are abundant the bait is also attractive to them, and the grouse trapping project may be ruined. (*Trap design from A. S. Hawkins and F. N. Hamerstrom. "Game Bird Banding Manual."* University of Wisconsin Game Management Division, 1937.)

breast feathers of the latter. Again, this indicator, like the others, is subject to variation. Determination of age, even to distinguishing between an adult and a fully developed juvenile, is next to impossible.

For *trapping grouse*, the funnel trap shown in Fig. 11·4 has proved effective. For several days before trapping is to begin, the trap with the cover removed is placed in the field and baited with corn placed on the ground inside the pen and also outside along the approach runway. The grouse, wary at first, soon become accustomed to the trap, entering through the trap

[1] From note in *Mich.* Conserv. **15**(7):13, August, 1946.

door and flying out when ready to leave. Once the birds have been thus conditioned, the top is replaced and trapping begins. To prevent the trapped birds from battering their heads against the wire mesh, the trap should be lined with fish netting.

For marking grouse, aluminum leg bands, wing markers of monel metal, and tail markers of colored pyralin are all suitable means of identification. Edminster (16) has successfully marked birds with colored feathers attached to the tail by wire or cement [1] and so placed as to be visible when the birds flush. If the color scheme and the point of attachment are varied, about 20 easily identified combinations can be devised. White, orange, yellow, and red have proved more suitable than other colors, being visible at greater distances and more readily distinguished. For dyeing the colored feathers, Edminster recommends the following procedure: White leghorn tail feathers (retrices, not coverts) are first immersed for a short time in a lukewarm solution of soap (5 grams of soap flakes in 1,000 cubic centimeters of distilled water), rinsed in cold water, then dipped for 1 or 2 seconds in the dye (8 grams of dye [2] dissolved in a solution containing 20 cubic centimeters of concentrated sulfuric acid and 380 cubic centimeters of distilled water), and finally laid out to dry on newspapers.

The *control of hunting* is an essential part of sound management for all game animals; but among species subject to cyclic fluctuations in population density, it has particular significance. In the case of the ruffed grouse special control measures instituted near the peak of the cycle appear to have no appreciable effect upon the wholesale decimation that follows, neither preventing nor delaying the full force of its impact. Whatever are the causes of this cyclic depression, hunting is not one of them. This cannot be said, however, of hunting during the critical period, immediately following decimation, when the population is recuperating from the catastrophe that has beset it. At that time the preservation of every bird possible is the only guarantee that recovery will proceed at an accelerated pace. Failure to invoke proper control measures at this critical period, such as closed seasons for 2 or 3 years, may seriously jeopardize the continuance of good hunting.

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[1] Duco household cement is suitable for this purpose.

[2] Wool yellow—Extra Concentrated; Wool Orange—2 G Crystals; and Croceine Scarlet MOO; National Aniline and Chemical Company, Buffalo, N.Y.

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CHAPTER XII

VARYING HARE

Lepus americanus [1]

GEOGRAPHICAL DISTRIBUTION

The varying hare, or snowshoe rabbit as it is sometimes called, gets its first common names from the fact that it changes the color of its coat from white in winter to brown in summer and its second because of the large size of its feet, an adaptation that enables it to live on top of the snow during the winter period. It also belongs to that group of animals which follow a cycle of abundance and scarcity, sometimes being particularly abundant and at other times relatively rare in the same locality.

In general the distribution of the snowshoe hare is limited to the Northern half of North America. It is found in the Eastern part of the United States as far south as Virginia in the higher altitudes of the Appalachian Mountains and as far south as Colorado and central California in the Western part of the continent.

ANATOMY, LIFE HISTORY, AND ECOLOGY

The color variation of the varying hare's pelage consists of a series of changes in which the old pelage is lost, is covered by additional hairs, or changed by the addition of a new coat. These processes take place on different parts of the body at different times so as to give a gradual change of color from brown to white in the fall and from white to brown in the spring.

Aldous (1) gives the pelage condition by seasons for Minnesota snowshoes as follows:

White pelage (winter coat)—December to March
White to brown (spring change)—March to May
Brown pelage (summer coat)—May to September
Brown to white (fall change)—September to December

The changes in the sexes are not identical according to Aldous (1). The females tend to enter the brown stage in the spring earlier than the males and to get their white coats earlier in the fall.

Much speculation has resulted as to the way the change of color is

[1] Anthony (*13 g.r.*) lists 12 subspecies of the varying hare in North America.

brought about in the pelage of varying hares. Anyone who cares to read the accounts of Grange (10), Aldous (1), and Severaid (17) will recognize this phenomenon as an orderly process of nature over which individual hares have no control.

Severaid (16), in confirming the work of Aldous and Grange, found that the changes were due to molting "complete on all parts of the body with the possible exception of the summer underfur during the autumnal

FIG. 12·1. Varying hare in winter. Nature intended the varying hare to blend in color with its surroundings. Sometimes, however, it is white when the surroundings are brown, and sometimes it is brown when the surroundings are white. (*U.S. Fish and Wildlife Service.*)

change. The renewal of the pelage is by new hair which is predominantly white in the pile and guard hairs but rufous or tawny in the underfur."

Severaid (17) advances the theory of monoseasonal hair growth, indicating that varying hares have two different sets of hair roots, one giving rise to the vernal brown coat and one developing the autumnal white coat.

In size the snowshoe is larger than the cottontail and smaller than the jack rabbit. Mature hares weigh 2½ to 4 pounds or possibly a little more (*13 g.r.*).

Breeding Characteristics. All the members of the rabbit and hare families are prolific. Varying hares breed the season following their birth, but no evidence is at hand to indicate if individual members of late litters breed later than early-born individuals. Mating takes place from March through August, the type of mating being promiscuous and similar to that of the cottontail (7, 15, 16, *66 g.r.*). As many as nine hares have been

observed in one mating process, eight of which were believed to be males (7). A female will breed the same day as the young are born (16). During the mating season the hares do a good deal of hopping about, fighting, and stamping on the ground with their hind feet. The gestation period is 36 days or possibly slightly longer (9, 16, 17). The number of litters per season may vary from two to four (1, 7, 13, 16). Aldous (1) states that the normal number of litters is two per season and that the number of young in a litter varies from two to eight, with the average about three. This has been confirmed by Green and Evans (13, 16). Severaid (16, 17) found that in captivity, several females produced four litters in a season, with the average number of young born per season per female being 7.5.

It has been suggested that a cyclic fluctuation may result from a reduction in the number of litters to one litter per season and a minimum number of young per litter, but Green and Evans (13) believe that exceptionally large losses of young hares account for the cycle. Severaid (16) found no appreciable correlation between the various points in the cycle and litter size but noted indications of an increase in the number of litters per season as the period of peak population is approached. The number of litters may not reach maximum numbers during the low point of the cycle owing to an interval of time between producing of the young and the next breeding activity.

The sex ratio of varying hares seems to favor the males. Of 1,625 hares examined by Aldous (1), 54 per cent were males and 46 per cent females.

The snowshoe hare appears to build no nest in which to deposit the young (1, 9, 16). The young when born are well covered with fur, have their eyes open, and are well developed. The mother nurses them until they are about 4 weeks old or possibly until she is ready to give birth to the next litter (16). Previous to the time of weaning, the young eat grass and other vegetation (9). Young snowshoes are practically full grown at 3 months of age.

Little is known about the interest of the male parent in the young. Presumably he takes no responsibility for their care and may even kill them if he finds them unattended. The mother is always in the near vicinity, however, and will fight to protect the young if the occasion arises.

Movements. Rabbits and hares are not extensive travelers when considered from the standpoint of changing the home range for different seasons of the year or from moving to different locations from year to year. During the process of trapping 853 hares in Minnesota, Aldous (1) found that 69 per cent did not move more than 1/8 mile, 17 per cent not more than 1/4 mile, 11 per cent between 3/4 and 7/8 mile, and slightly more than 3 per cent moved a mile or more. Seton (*88 g.r.*) gave the home range of the snowshoe as 20 to 30 acres in dense cover and possibly twice this much in

open cover. In common with the cottontail, the male hares are inclined to travel the greater distances.

Cover Requirements. The ideal cover type for the snowshoe is a mixture of hardwoods and conifers, hardwoods for food and conifers for protection. Hares are seldom found in any cover not having a sufficient density to shield them from detection from above, and apparently some of the vegetation must be coniferous. In relation to life zones Seton (*88 g.r.*) says that its chief abundance is in the Canadian zone, and in the Hudsonian it is less plentiful. The Canadian zone extends to the southern border of the spruce and fir forests and the Hudsonian to the northern border of coniferous trees.

Grange (9) comments as follows on the snowshoe of Wisconsin in relation to cover: "The amount of underbrush largely determines the desirability of any particular range, and the lack of a goodly portion of either aspen or balsam fir or both seems to be the limiting factor in many cases." He lists different forest types as follows:

Aspen areas are a favorite habitat if they contain coniferous species—balsam fir and cedar—or are adjacent to coniferous swamps. Coniferous swamps may be used all year even without aspen. Hardwoods are used only if some coniferous cover is present. Cedar swamps are used extensively regardless of whether the major crown composition is hardwood or conifer. Mature hemlock are used if brushy areas are adjacent. Alder and willow swamps are favorite haunts of the snowshoe hare, as are recent burns that have had time to fill in with aspen, thimbleberry, and tangles of woody vines. Jack pine is also used if adjacent to aspen. Within the zone in which the varying hare is found, it is apparent that the materials needed for food and cover must be quite universally present or else the hare would be more spotty in its distribution. The difference in hare densities on different parts of the range is evidence that certain plant elements are needed for a hare range. The Berkshire Hills in New England appear to be ideal as far as one can tell by visual estimate; yet nowhere in this area does the hare attain a population density approaching that found in parts of Wisconsin and Minnesota. The one striking difference in the two ranges appears to be the presence of aspen in the Lake states and the lack of appreciable quantities of aspen in the Berkshires. MacLulich (15) found coniferous swamps, willow-aspen swamps, second-growth poplar-birch on burns, and cutover areas the most commonly used habitats in Canada.

Food. Snowshoe hares eat buds, bark, roots, and stems of woody plants as well as various parts of herbaceous plants. Aspen seems to be the favorite food species among the woody plants, but its universal use may be explained by the extensive distribution of this tree species on the range of the hare. Other deciduous trees are eaten as well as many conifers.

A list of plants eaten by snowshoes at different seasons of the year in Minnesota, Ontario, and Massachusetts is given in Table 64.

TABLE 64. PLANTS LISTED AS FOOD OF THE VARYING HARE IN MINNESOTA, ONTARIO, AND MASSACHUSETTS

Minnesota (1)	Ontario (7)	Massachusetts (8)
	Fall *	
Willow Trembling aspen *Lycopodium*		
	Winter †	
Willow Birch	Trembling aspen Bur oak White spruce Hazelnut Bog birch Wolf willow Rose Willow Plum Cherry	Wintergreen Red oak Red maple Norway spruce Bush honeysuckle Low-bush blueberry Hemlock Chestnut
	Spring *	
Trembling aspen Willow Birch Strawberry Everlasting Dandelion Clover Horsetail Grasses	Summer grasses Oats Wheat Barley Fall rye Dandelion Alfalfa Vetch Peas Wild aster Garden vegetables	

* The summer food probably includes food eaten both spring and summer. Winter food includes those eaten in late fall and winter.

† Gould's study involved only winter relationships.

Hosley (*56 g.r.*) adds the following to this list of species of plants used for food: soft maple; balsam fir; tamarack; black spruce; scotch, jack, white, and red pines; hazel; sumac; northern white cedar; apple; speckled alder; dogwood; raspberry; blackberry; and oleaster.

Criddle (7) and MacLulich (15) both mention that snowshoes eat frozen flesh when it is available. Several investigators noted that hares

consume varied quantities of soil and may also gnaw on bones and deer antlers. The apparent need of the snowshoe for minerals manifests itself in the animal's seeking minerals from various sources. Gould (8) states that the amount of food eaten by a snowshoe hare over a 24-hour period amounted to about $1\frac{6}{10}$ pounds. MacLulich (15) estimates the quantity of aspen bark needed for a hare for one winter as amounting to the bark between the ground line and 2 feet above the level of the snow on 14 trees $2\frac{1}{2}$ inches in diameter. In addition the animals consume a small quantity of other wood.

Severaid (16) found that in captivity hares consumed from $\frac{1}{4}$ to $\frac{1}{2}$ pint of water apiece per day during the summer.

Population Density. In the locality of optimum range varying hare populations fluctuate from year to year, at times being very high and at other times being almost nonexistent. Seton (*88 g.r.*) speaks of snowshoes fluctuating from 1 per square mile to 10,000 per square mile, the latter being equal to about 15 per acre. It is also probable that a density of 15 snowshoes per acre would never be found except on an ideal range and can therefore be considered as the absolute extreme of abundance. Criddle (7) gives 5 hares per acre as a high population and a low of 1 per 10 acres on a 100-acre tract. Grange (9) gives a high of 1 hare per acre on 40 acres in Door County, Wisconsin.

Excellent evidence is available from Green and Evans (13) on the snowshoe population of 6.5 square miles near Lake Alexander, Minnesota. Here the February varying hare population fluctuated from a high of 500 animals per square mile in 1933, or a mature hare for each 1.25 acres, to a low in 1938 of 32 animals per square mile, or a mature hare for every 20 acres. It was believed that greater density occurred following the breeding season in 1933 when Green and Evans (13) calculated that there were something over 1,500 animals (young and adults) per square mile, or more than 2 hares to each acre.

Miscellaneous Habits. *Individual Ranges and Migrations.* As already indicated, the home range of the varying hare is relatively small, frequently not more than 20 to 25 acres and often much smaller (1; *88 g.r.*). Banding returns have shown that hares spend their lives on a very limited area and seldom move more than $\frac{1}{4}$ mile and rarely more than a mile (14). Cases have been noted, however, where snowshoes have moved to new territory, mass migrations up to several miles being noted. Cox (5) describes such a migration where the hares moved across a lake apparently to reach new territory where the population pressure was less and perhaps to seek new food supplies. Criddle (7) also speaks of hare migrations in Manitoba extending from 8 to 15 miles in length. Migrations are apparently typical of hares during the peak of a population cycle and not general in all localities.

Runways, Holes, Forms, and Dusting Places. The snowshoe hare is one of the few animals that build runways as a definite part of their seasonal activities. These runways are apparent both in summer and winter. The runways in summer are very conspicuous in sphagnum swamps, and in the winter they show as hard-packed snow trails in the swamps. Their usefulness is apparent. They furnish easy highways for the animals to get their food supply and also as avenues of escape when the hare is pursued by a predator. Criddle (7) considers these runways as important to the safety of the snowshoe as its protective coloring. The use of holes and forms by the snowshoe is apparent in nearly all parts of its range. Grange (9) refers to it in Wisconsin, and it is also referred to by Aldous (1) for Minnesota and by Criddle (7) and MacLulich (15) for Manitoba and Ontario. Holes are probably less used in the southern parts of the range than farther north. Severaid (16) states that hares in captivity did not make burrows.

The form may be a place in a bunch of grass or in a clump of brush or an opening beside the upturned roots of a fallen tree. These forms are the daytime resting place and may be used throughout the year. Grange (9) speaks of forms being found in burned areas as well as on hillsides where they can get the full rays of the sun. Hares may remain in dens or forms during periods of storms and until the weather is favorable.

The dusting spot is a place where dry, powderlike dust is available and appears to be used to give relief from external parasites. Severaid (16), however, found hares dusting when they had no ticks. Charcoal ashes and fine soil may be used for the dust bath. It is believed the dusting spot is not an individual affair but may be used by any of the hares in the vicinity as well as by ruffed grouse (1, 15).

Cycles. Cycles of abundance and scarcity appear to be about 10 years in length (2, 3, 4). The die-off does not take place in all localities in the same year, as is indicated by MacLulich (15) in the following statement:

> For Canada as a whole, the cycle appeared to reach a peak earliest in the coastal districts of the Maritimes and the St. Lawrence Valley, the delta of the Mackenzie River, and British Columbia and latest in the northern part of the Canadian life zone and the southern parts of the Hudsonian.

Years of high population densities of varying hares are given by MacLulich (15) as follows: 1808–1815, (no date) to 1845, 1853–1855, 1863–1864, 1875, 1885–1886, 1895, 1904–1905, 1912–1913, 1922–1923, 1932–1934.

During the low of a population cycle only the choice parts of the range are occupied (15), but at the peak all sites are used. With respect to the age of dying hares during "crash" years, Green and Evans (11) found that the young of the current season (calculated as constituting normally as high as 97 per cent of the population) were the ones that die off. While

under normal conditions, the yearly mortality occurs during the winter months, in the years of the "die-off" it occurs during the summer months. The period of the decline may last over a period of several years. Green, Larson, and Bell (14) indicate that a condition referred to as "shock disease" is the mechanism which causes death and therefore the cause of cyclic fluctuations. (See chapter on Variations in Numbers of Wild Animals.)

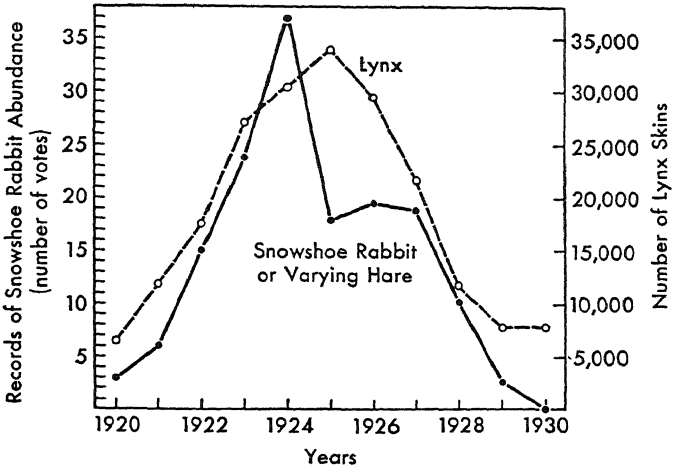

FIG. 12·2. Solid line connects points showing number of observers recording rabbit abundance during 1920–1930. Broken line shows lynx production for all of Canada during the same period of time. (*Dominion Bureau of Statistics, Ottawa, Ontario.*)

MANAGEMENT

Census. Two methods appear to be satisfactory for estimating varying hare populations. The first consists essentially of a trapping and tagging process, followed by a second period of trapping. This method is described in principle under the techniques used in making a census of cottontails and has proved successful according to Green and Evans (11, 12). Green and his associates used 60 box traps at 182 established trapping stations on 6 square miles. The precensus trapping was carried on from October to April, and each hare caught was marked with an ear tag. The final 2 or 3 weeks were used for the census, each station being trapped for 6 trap nights. The bait used consisted of small bundles of alfalfa dampened with water and frozen together. The population is calculated on the basis of three known factors, *i.e.*, (1) the total number tagged during the precensus trapping period, (2) the number of tagged, and (3) the number of untagged hares caught during the census trapping periods.

The second census method for varying hare is the system that Webb (18) has devised. This is a variation of the King grid-census method used

for ruffed grouse (see chapter on Ruffed Grouse). The census lines used are $\frac{1}{4}$ mile apart and cross the census area at right angles. In censusing hares, a record is made of the distance from the observer to where each animal is "jumped" as well as the angle of the hare in relation to the direction of the line being traveled. Both of these values are averaged on the basis of all hares started. The width of the sample strip is then computed by taking the value of the average "jumped" distance as the hypotenuse and calculating its position in relation to the census line by using the sine of the average "jumped" angle. The formula to get the total population is given by Webb (18) as follows:

$$P = \frac{AZ}{2XY \sin D}$$

P = population
A = total area in square yards
Z = number of hares seen
X = length of census line in yards
Y = average "jumped" distance in yards
D = average "jumped" angle in degrees of arc

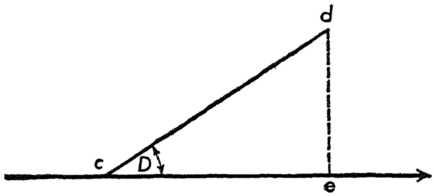

FIG. 12·3. Method of computing varying hare census.
c = position of census taker
d = position of hare as it is "jumped"
de = altitude of triangle cde
D = angle of "jumped" hare to line of travel

Webb (18) gives the following results obtained on 2,520 acres of varying hare range in St. Louis County, Minnesota.

TABLE 65. VARYING HARE POPULATION ON A 2,520-ACRE SAMPLE TRACT IN ST. LOUIS COUNTY, MINNESOTA (18)

Date	Length of line, miles	No. of hares "jumped"	Average "jumped" distance, yards	Average "jumped" angle, degrees	No. of hares per square mile
Oct. 30–Nov. 1, 1935	32.7	34	6.1	33°58′	268
Jan. 9–10, 1936	32.0	19	10.5	31°46′	94
Apr. 1–3, 1936	36.8	14	14.1	31°45′	45
Oct. 12–13, 1936	32.7	13	5.3	35°41′	113
Jan. 12–15, 1937	34.0	9	11.1	33°52′	38

Procedures for Increasing Varying Hares. Several states in the Eastern part of the United States purchase varying hares each year to restock the covers and to furnish sport for hunters. As hare populations

become depleted in the states where they are now trapped and as the traffic in hares diminishes, new methods will be sought to make local hare habitats more productive. In parts of Canada where both the meat and fur are valuable, the manipulation of the snowshoe range is likely to get increasing attention. The hare is not suited to agricultural lands and seems definitely to be limited in its range by the lack of a particular combination of vegetational varieties. In the Lake states Leopold (*66 g.r.*) believes that the drainage of tamarack swamps has caused the snowshoe range to recede northward. In New England it appears to be limited to areas in which there is spruce or pine of young age classes or mountain laurel. In the Canadian prairie the alder-willow thicket seems to be a favored cover type. In studying the habitat of the varying hare in north-central Massachusetts, Gould (8) found that a low, dense type of cover was needed to make an area habitable for hares. This need was met at Petersham, Mass., by plantations of conifers in the early stages of growth together with the hardwood sprouts that always spring up in coniferous plantations. After 25 years of age coniferous plantations become less desirable for snowshoes. Gould also mentions the value of thinnings and weedings to produce food and cover for the hares if the material cut is left on the ground. In the Lake states it appears that the planting of spruce in or along alder swamps should improve the varying hare's range, and the closing of drainage ditches in tamarack swamps should again make these swamps habitable to hares.

Severaid (16, 17) has demonstrated that snowshoe propagation in pens is practical and that the animals could be produced for about $1.25 each.

Procedures to Reduce Damage by Snowshoe Hares. The snowshoe hare has destroyed many acres of forest plantations in the Lake states, particularly during the years when numbers of hares were at the "high" stage of the population cycle. Whole blocks of plantations have been destroyed within a year or two following planting. Foresters have suggested that planting be done only during the "low" of the cycle. This is not a practical solution, however, as hares go through both a low and high population fluctuation during a 10-year period, while trees need from 10 to 15 years to reach a height of 3 to 5 feet, the size needed to take them beyond the danger of damage from these animals. Likewise, large forest nurseries involve heavy investments and do not lend themselves to irregular annual production (*66 g.r.*). Poisoning is a possible solution but is both expensive and unsatisfactory because of the waste of a resource and the accidental destruction of other animals not a menace to the forest. Cox (6) suggests that the snowshoe is an asset rather than a liability because of its value in thinning the forest stand. Possibly this was true before man took a hand in removing the timber by logging and burning,

but certainly a 90 per cent thinning of white pine planted 6 by 6 feet is not a desirable operation from the angle of correct silviculture.

Certain practices suggest themselves as being of value in protecting conifer plantations from varying hare damage:

1. *Retain the enemies of varying hares, including timber wolves, coyotes, bobcats, lynx, and the great horned and barred owls.*

2. *Plant susceptible species like white pine on the more open lands away from favorable habitats of the snowshoe.* If only species of conifers are to be planted, use less susceptible ones like jack pine and balsam fir next to the swamp borders.

3. *Keep all plantings out of brushy thickets where varying hares travel and feed freely.*

4. *Surround swamps suitable for varying hares by lanes of open land* 50 *to* 300 *feet wide.* This can be done by controlled burning or removing the vegetation with power machinery.

Control by Direct Methods. Shooting, trapping, and snaring are all methods that have some value in the control of varying hare surpluses. The U.S. Forest Service Wildlife Handbook (*7 g.r.*) suggests shooting as being most effective after the coat of the snowshoe has changed to white but when there is no snow on the ground or in the spring when the coat has turned brown but when snow is present. Snaring has been found to be a good method of taking hares during the winter season. When snow forces the animals to travel in runways, snares are particularly effective. Snare wires are about 2 feet long, either of No. 22 tinned wire or No. 2, 12-strand picture cable wire. The hook through which the opposite ends of the wire slides is ⅛ inch across or slightly larger in diameter; the snare loop is 4 to 6 inches across and placed directly in the runway. The snare opening is so placed that the hooked end slides freely along the other side of the snare. The wire loop is fastened above the runway on a stick set in the snow, and the free end is fastened to a sapling. One man can tend three lines of 75 to 100 snares each by visiting each line of snares once every 3 days. If the hares are wanted alive, a button is placed on the snare loop so as to prevent the loop from closing far enough to strangle the animals yet tight enough so as not to allow the loop to slip over its head.

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CHAPTER XIII

WILD TURKEY

Meleagris gallopavo spp.

GEOGRAPHICAL DISTRIBUTION

The first Thanksgiving turkey, now the symbol of America's bountiful life, came from the wild flocks that formerly flourished in much of the climax forests of the Eastern United States. Familiar to most are the picture of early colonists plodding homeward, blunderbuss across shoulder, and from it slung a magnificent gobbler, indicative of the plentiful wildlife that inhabited our forests in their primeval state. Oak, chestnut, and beech provided abundant food; and wherever these trees comprised a large part of the forest, the wild turkey thrived.

The original range of the turkey included 39 states, wholly or in part (see Fig. 13·1) (29). Today, as a result of settlement and the clearings of forests, the limit of distribution is greatly reduced, touching upon 20 states and occupying not more than 20 to 30 per cent of its former area in the United States (23). If we judge the future from the results of the past 50 years, we should conclude that the range of the species, as well as the present stock, is due for additional reductions. The fact remains, however, that several states have sufficient stock to permit an open hunting season. It is the hope, now that attention has been focused on the turkey and specific attempts made to improve its lot, that its number will increase rather than decrease under the aegis of proper management.

In relation to former numbers wild turkeys are now at an exceedingly low point. However, several states have satisfactory numbers of wild stock, and in some localities these stocks are increasing. In 1938 Virginia had a total of 22,575 wild turkeys on about 14,000 square miles of range and an annual kill averaging slightly less than 7,000 birds (24). Pennsylvania has a turkey range of approximately 2 million acres and an average annual take of about 3,800 birds. The maximum yearly take in Pennsylvania may total as high as 6,000 turkeys (14). In Missouri 31 of the 114 counties contained turkeys in 1942 on a range of approximately 7,000 square miles with a population of more than 4,000 birds (17). Texas harvests an estimated 8,000 wild turkeys a year and has extensive range suited to these birds (32).

The species, *Meleagris gallopavo*, is represented by six subspecies: the

eastern turkey, *M. g. silvestris* Vieillot, found throughout the range from Texas eastward; the Florida turkey, *M. g. osceola* (Scott), of southern

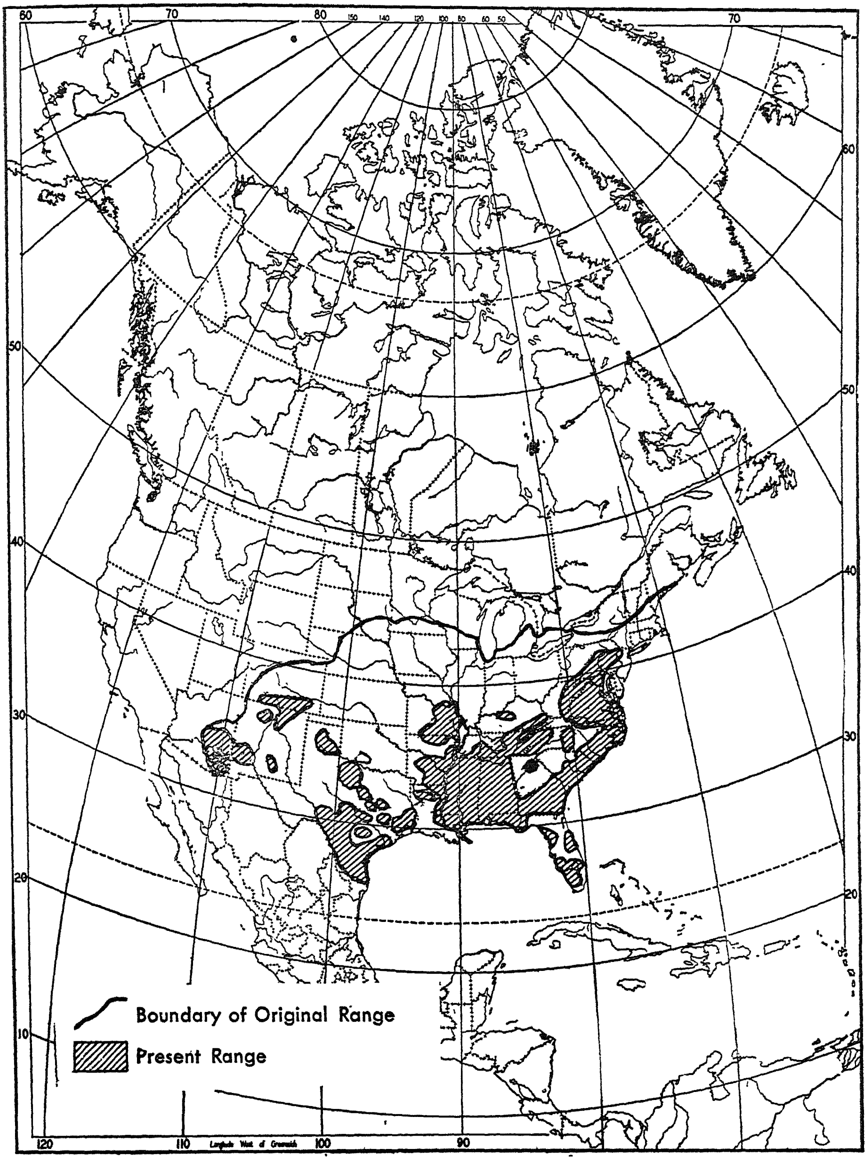

FIG. 13·1. Range of the wild turkey. (*By Henry S. Mosby and Charles O. Handley*, 1943.)

Florida; the Rio Grande turkey, *M. g. intermedia* (Sennet), indigenous to southern and central Texas and northeastern Mexico; Merriam's turkey, *M. g. merriami* (Nelson), occurring in the Rocky Mountains from southern

Colorado to northern Mexico; *M. g. gallopavo* (Linne) in northeastern Mexico; and *M. g. onusta* (Moore) in northwestern Mexico (*20 g.r.*, 24).

LIFE HISTORY AND ECOLOGY

Breeding Characteristics. The breeding period of the wild turkey begins with the breaking up of flocks of both sexes into smaller groups of separate sexes and also a separation of old and yearling males. Gobbling of the mature males begins in February and March in Missouri, depending on favorable weather (16). Mosby (20) places the breeding period in Virginia from March to July. As the mating season approaches, the older toms leave the winter flocks, select individual breeding ranges, and attempt by dint of lusty gobbling and pompous strutting to entice the females into their territory. The more successful birds may thus acquire a harem of as many as ten but usually no more then five or six hens. The courting gobbler rarely if ever seeks out the females, the latter coming to their favorite male in response to his calls. Mating proceeds throughout the period of laying or until the tom is emaciated and exhausted, mating usually taking place once daily for each member of the harem. The wild yearling males keep to themselves at this time or follow the older toms but are not capable of breeding (*66 g.r.*, 12, 16, 22).

Mid-April marks the start of nesting activities. The nest, a makeshift affair consisting only of a shallow depression in the forest floor, is well concealed in thick undergrowth, beneath brush, or in herbaceous vegetation. Some nests are placed in very open situations with meager concealment. Leopold (16) noted in Missouri that the nest is always near water. Its precise location is closely guarded both from predators and from the breeding male lest the eggs be destroyed. Egg laying is at first irregular, but later one egg is laid each day (3). The number of eggs varies from 7 to 16, although larger clutches of 18 to 20 sometimes occur. The average size of the 40 clutches reported by Mosby (22) in Virginia was 11.3 eggs, and wild clutches averaging 10.5 eggs for 8 nests have been found in Missouri (16).

During the period of egg laying the female leaves the nest daily but thereafter devotes her attention to incubation almost wholly, rarely leaving the nest except in the early stage of incubation to dust, feed, and drink. Later she remains on the eggs almost constantly. Incubation requires about 28 days (24). If the first nesting effort fails, a second may be attempted, but the fertility of the eggs of the second clutch is likely to be lower, particularly when this clutch is laid late in the season (22). In Missouri 80 per cent of the first nests of native birds hatch in June, but hybrid stock incubates earlier (16).

After the eggs hatch, the brood remains in the vicinity of the nest for several days while the poults gain strength and learn to eat. At about 4

weeks of age they are able to take short flights. For the remainder of the summer and even during the fall the brood roams the range with the mother. Sometimes the family group is joined by an immature male of the previous season or a hen that has not been successful in bringing off a brood, but in general the fall flock consists of the mother and brood of the current year (24).

Movements. The turkey, in contrast to most other important game birds, is decidedly active in its daily movements, traveling considerable distances in search of food, water, and dust baths. Although the quail, pheasant, and grouse restrict their daily activities to a cruising radius that rarely exceeds a mile, the turkey not uncommonly covers several miles in securing a single meal. Frequently as much as a mile may be traversed in a single flight (14).

The usual daily routine, except during the mating and nesting seasons when movements are less extensive, consists of foraging in the neighborhood of suitable roosting cover, to which the birds often return night after night. The daily quest for subsistence commonly proceeds up the slopes into cover types where food is abundant and undergrowth of only moderate density. Travel of the eastern turkey is principally on foot, flight being resorted to only when the birds are disturbed (28). The Rio Grande turkey, however, may fly considerable distances to roost.[1] In general, flight serves as a means of escape or of quick transit to other parts of the range. Tall trees situated on low ground along watercourses and around ponds provide favorite roosting sites, particularly trees that are sheltered from the wind (22) or permit the birds to sit over open water (*20 g.r.*). Rutledge (27) says that turkeys often roost in deciduous trees even when the leaves are off, but are well camouflaged because of their similarity in appearance to Spanish moss, mistletoe, or squirrel nests.

Seasonal behavior is not dissimilar to that of a number of other game birds. During the summer the female and her brood continue their gregarious existence, but the males tend to lead a solitary life. With the arrival of colder weather the situation changes and the formation of winter flocks begins. The adult males, forsaking their life of seclusion, band together in small groups of three to five birds each on the average. Meanwhile, the females, young of the current year, and yearling males form other groups, the two sexes mingling freely in the same flock. Sometimes the range of several flocks merge into "droves" (16). During this period it is likely that family ties are weakened, so that birds forming one of the mixed flocks may be representatives of several broods, and the birds of a single large brood may be scattered among a number of separate flocks. During this fall flocking period there are a series of miscellaneous move-

[1] *Quart. Prog. Rpt.* October, December, 1941. Texas Game, Fish and Oyster Commission, Division of Wildlife Restoration, pp. 21–23.

ments away from the summer and fall feeding grounds to the winter feeding grounds. Leopold (16) refers to this as a period of fall wandering, the purpose of which appears to be to locate a winter food supply—usually to a locality where mast or other winter food is abundant. This movement may extend as far as 4 miles or farther. After a suitable winter food supply is located, the daily routine goes on. Leopold (16) speaks of identifying one flock of wild birds eight times, their range covering an elliptical area of less than 4 square miles.

The winter aggregation remains together until winter or early spring, when the females break away from the mixed flocks and the groups of adult males disband. During the mating periods the juvenile males keep to themselves, carrying on normal nonbreeding activities.

Cover. The turkey is typically a bird of the forest, but the western border of the range formerly extended far into the prairie. At present, however, no range containing predominantly nonforest types provides a suitable habitat. Ideal cover is characterized by a diversity of forest cover types and age classes well interspersed with small openings and some cultivated land. Openings and cropland should comprise between 10 and 30 per cent of the total range (14, 22). Leopold (*66 g.r.*) recommends range containing one-half woodland, one-quarter brushland, one-eighth grassland, and one-eighth cultivated land. Mosby and Handley (24) question the value of brushland for the eastern turkey but hold that it may be of importance for the Merriam's turkey. In Missouri Dalke and Leopold (17) consider range that contains "balds," or open-faced hillsides, as ideal turkey range. Formerly, when the better soils were forested or supported a combination of forests and open spaces, these sites were the highest producing turkey range. The use of hillsides and land marginal for agriculture by wild turkeys is the result of occupancy of the better soils for farming.

The woodland portion of the range should consist primarily of deciduous species, especially those producing mast, but at least a small representation of conifers is desirable. Forest having both young and old age classes is superior to either alone, and older stands with moderate undergrowth are preferable to types where ground cover is dense. Grassy openings and open stands offer suitable nesting cover. Openings with herbaceous vegetation and cultivated lands, especially if grasses are present or if planted to grains, are both desirable, the first providing food for winter and spring, the latter providing food for summer and fall. The best turkey range in the original forests occurred in the hardwood regions on lands where oak and chestnut were abundant and small openings prevalent (24). Northward, beech was an important component, and southward a suitable habitat was provided by mixed stands of oak and southern pines.

Food. The diet of the turkey is characterized by a pronounced prefer-

ence for vegetable materials in general and fleshy fruits, mast, and green leaves in particular. The former are important from midsummer to early winter; the latter during the fall and winter. Miscellaneous seeds, including grain when available, comprise most of the remaining vegetable materials. Insects, especially grasshoppers, are consumed freely at seasons when their numbers are high, but even then the diet is predominantly of vegetable origin.

Mosby and Handley (24) studied the contents of 524 wild turkey stomachs collected over a period of years from 1886 to 1941 during all months of the year. A total of 667 species of both plants and animals were identified from the materials contained in these stomachs. Plants represented 354 species, and 313 animal species were identified. The apparent equal numbers of plant and animal species are misleading in terms of the principal food of the eastern wild turkey, however, as plant foods constituted 94.74 per cent of the diet and animals only 5.25 per cent, with 0.01 per cent undetermined. Of the vegetable foods 11 plant species alone comprised 70.85 per cent, while various species of insects formed 4.69 per cent of the total diet (see Table 66).

Data on food preferences of the wild turkey throughout the year based

TABLE 66. IMPORTANT PLANT AND ANIMAL FOOD OF THE EASTERN WILD TURKEY AS INDICATED BY THE CONTENTS OF 524 STOMACHS COLLECTED IN VIRGINIA (24) *

Items	Per Cent of Total Food Eaten
Plant foods:	
Oaks (*Quercus* spp.)	27.84
Dogwoods (*Cornus* spp.)	14.35
Grapes (*Vitus* spp.)	6.18
Gramineae (other than corn)	7.56
Corn (*Zea mays*)	5.60
Greenbriers (*Smilax* spp.)	1.94
Poison ivy (*Rhus toxicodendron*)	1.91
Gums (*Nyssa* spp.)	1.82
Beech (*Fagus grandifolia*)	1.43
Ash (*Fraxinus* spp.)	1.21
Sumac (*Rhus* spp.)	1.01
Total	70.85
Animal foods:	
Insects:	
Orthoptera	2.29
Diptera	1.47
Miscellaneous	0.93
Total	4.69

* Only items amounting to 1 per cent or more are listed.

on stomach analyses are lacking. Judd's early work (*58 g.r.*) based on 16 stomachs collected at all seasons shows the following distribution of food by classes:

	Per Cent
Browse	24.8
Fruit	33.0
Mast	4.6
Grain	Trace
Miscellaneous seeds	20.1
Miscellaneous vegetable materials	1.9
Insects	15.2
Miscellaneous animal materials	0.4
Total	100.00

These values are noteworthy for the high percentage of browse and the low percentage of mast. In these respects Judd's findings disagree with other analyses and discussions of food habits. Grain occurred in but one stomach, which is perhaps not unexpected nor atypical, for in heavily forested range of the type commonly frequented by the turkey cultivated land may be entirely lacking.

On the other hand, 15 stomachs collected in Pennsylvania during November, 1938 and 1939, contained grain in abundance, suggesting that where these materials are available, they provide a favorite food (1). The principal plants represented are wheat, 39 per cent; corn, 24 per cent; oak acorns, 10 per cent; grass leaves, 10 per cent; and grapes, 4 per cent. Animal matter amounted to 2.3 per cent. A study of food habits of Pennsylvania wild turkeys for the entire year was made by Kozicky (13) from analyses of droppings. Results as summarized by that investigator are as follows:

Acorns, grasses, and sedges, wild grapes, dogwood, wild cherry, and snails are natural foods that are taken at all seasons of the year. Acorns are the one most important item of food for all seasons except summer. During this season acorns are superseded in amount eaten by grasses, sedges, huckleberries, and wild grapes.

The following table based on data from stomachs collected from a region where agricultural crops are not plentiful is perhaps the best example of the typical winter diet of birds inhabiting the eastern range. This investigation clearly demonstrated that food habits vary with the availability of favored materials. During the 3-year period in which data were collected, the representation of grapes in the diet fluctuated with the size of the crop, being 51 per cent of the total one year while less than 1 per cent in another year and thus indicating clearly the value of this plant when it is available.

Stoddard (30) lists the following as important winter foods for wild

TABLE 67. EARLY WINTER FOODS OF WILD TURKEY AS SHOWN BY THE ANALYSES OF 115 STOMACHS COLLECTED IN VIRGINIA AND WEST VIRGINIA (19)

Item	Per cent of total stomach contents	Item	Per cent of total stomach contents
Fleshy fruits	36.4	Dry fruits and seeds	38.1
Grapes	18.7	Oak	14.8
Flowering dogwood	10.0	Corn	10.7
Greenbrier	2.2	Ash	4.2
Black gum	2.0	Eupatorium	2.7
Blueberries	1.8	Nimble Will	1.9
Persimmon	1.7	Dutchman's pipe	1.5
Green foods	5.2	Crabgrass	1.3
Grasses	3.9	Buckwheat	1.0
Vetch	1.3	Insects	6.2
All other plants	13.5	Miscellaneous animal matter	0.6

turkeys in the Southeast: seeds of pines and fruit of oaks, cypress, sweetgum, magnolia, beech, grapes, greenbrier, and flowering dogwood. These materials are supplemented by underground roots and tubers like nut grass, seeds of herbaceous plants, and miscellaneous animal matter. Foods consumed during the summer include insects, the seeds of grasses, and fleshy fruits of blackberry, dewberry, and huckleberry. In addition to these materials, Judd (*58 g.r.*) mentions the fruit of wax myrtle, cedar, spicebush, southern tupelo, holly, myrtle holly, strawberry, and mulberry. The Merriam's turkey, he states, feeds extensively upon pine seed, especially the piñon pine, and the berries of western junipers.

Two other studies of wild turkey feeding habits, one in Missouri and one in Alabama, give pertinent additional facts concerning food on these important turkey ranges. The Missouri studies are based upon analyses of 3,244 droppings collected during every month in the year, while the Alabama results are obtained from an examination of 116 crops and gizzards from turkeys collected during the spring shooting season, Mar. 15 to Apr. 15, for 3 years (1937, 1938, and 1939). In Missouri according to Dalke, Clark, and Korschgen (7), 75 per cent of the turkey diet is made up of plant materials and 25 per cent of animal origin. The proportion of animal food is highest from April to October and consists largely of insects. Plant materials are most completely utilized from September to April and are made up of a wide variety of species. Only a few items of either plants or animals are of great importance in terms of bulk of food eaten, however, the two most important items being acorns and grasses. Fleshy fruits of blackberry, cherry, blueberry, and mulberry are eagerly sought when fresh, and seeds of various grasses and sedges are also used.

In Alabama the spring food of the wild turkey is more than 88 per cent plants by volume (9). Even during the spring season acorns are the most important single item and are classed as a staple food. Mast of beech, gums, and dogwood is also utilized. More than 80 per cent of the stomachs examined contained animal food during this period, indicating the preference of turkeys for insects even at a period of the year when insects are not particularly abundant.

The work of Mosby and Handley (24); Dalke, Clark, and Korschgen (7); Good and Webb (9); and Kozicky (13) all suggest the importance of a few items in the diet of the eastern wild turkey, the most important of these being the mast of oaks, ash, dogwood, smilax, and beech.

Water and Grit. Leopold (*66 g.r.*) states that turkeys require free water for drinking purposes, but Stoddard (30) implies that they are able to do without it when succulent foods, like fleshy fruits, are available in abundance. Grit is essential to digestive processes, and gravel or hard seeds are usually present in the gizzard. Fleshy fruits are probably digested without difficulty, but certain types of mast, like acorns, require considerable grinding. Fifteen stomachs examined by Bennett and English (1) contained 2 per cent gravel. The volume of grit as found by Kozicky (13) in wild turkey droppings in Pennsylvania varied from 5.2 per cent in spring to 3.0 per cent in summer to 1.6 per cent in the fall and 1.7 per cent in the winter. Apparently this variation merely reflects the abundance or scarcity of grit during the various seasons. When grit is most plentiful in the droppings (spring and summer), it is most available in the environment. At other seasons when it is less available, less would pass through in the droppings. A majority of the stomachs examined by Mosby and Handley (24) contained grit, the amount ranging from none to 25 cubic centimeters. The average of one lot of 137 stomachs contained 7.1 cubic centimeters of grit per stomach.

Population Density. Virginia, which may be regarded as good turkey range for the Middle Atlantic states, carried an estimated fall wild turkey population in 1937 of 2,100 flocks comprising 23,000 birds, most of which occurred on about 34 per cent of the state's total land area (24). This is a population density of one bird for each 380 acres of inhabited range and one flock for each 6.6 square miles. On Missouri's turkey range the population in 1934 was estimated to be one bird for each 1,800 acres. A later and more accurate count of wild turkeys in Missouri made in 1942 is now available and is based on census data collected by Leopold and Dalke (17). The Missouri range consists of 7,000 square miles (4,480,000 acres) of semiwild land supporting 590 flocks or a total of 4,340 turkeys, or a bird for each 1.6 square miles (1,024 acres). The population is not uniformly distributed over the entire area, however, some portions of the range being

more densely populated than others. This difference in population density is given as follows:

No. of turkeys per township (23,040 acres)	Total area with this density, square miles	Per cent of total Missouri range
1–20	4,130	59
21–40	1,750	25
41–60	1,120	16

Leopold (16) gives the 1942 turkey population on the Caney Mountain Refuge (5,500 acres) as 140 birds, or one turkey for about every 39 acres. Drury Refuge (4,600 acres) had a population of 191 birds, or one turkey for approximately every 24 acres. These data approach the figure given by Stoddard (30), who estimates that it is possible under intensive management to carry one turkey for each 15 to 25 acres of good range in the Southeast.

MORTALITY

Mortality before Hatching. Because of the paucity of information on this subject only tentative conclusions can be drawn. It seems likely that turkey eggs are subject to the heavy loss typical of other ground-nesting birds. Mosby's (22) work in Virginia lends support to this belief, although his belief is that the turkey fares somewhat better in this respect than some other game birds. Of the eggs in 40 nests observed by Mosby, 57 per cent were destroyed or failed to hatch, with desertion accounting for 31 per cent and the remaining percentage being attributable to the following agencies: man, 10 per cent; skunks, 4 per cent; crows, 3 per cent; unknown and miscellaneous causes, 9 per cent. Turkeys reared in captivity and then released were hardly more successful, bringing through but 60 per cent of their eggs. With such birds losses were due mainly to skunks, crows, and carelessness of the hen; none to desertion.

In cases of nest desertion free-running dogs and hogs are frequently the responsible agents, probably causing greater mortality in certain localities, particularly southward, than all other predators. The belief that male turkeys sometimes destroy nests and may even kill young poults is well authenticated, but there is little reason to believe that this factor ever assumes major importance.

Losses Caused by Predators. Evidence, sparse as it is, suggests that decimation through predatory loss is confined very largely to nest mortality and immature birds. Older birds, though doubtless preyed upon occasionally by larger animals such as dogs and bobcats, are relatively safe from

attack under most circumstances. Nesting turkeys have been reported killed by foxes, raccoons, bobcats, eagles (in Arizona), and moccasin snakes, and poults by foxes, bobcats, and great horned owls (22). Additional evidence is furnished by Bennitt and Nagel (*19 g.r.*), who report that hunters, game wardens, and park keepers whom they questioned in Missouri attributed most of the predatory losses including nest mortality to foxes, hawks, owls, crows, skunks, and wolves. It must be borne in mind, however, that many of these opinions probably were based on casual observation or hearsay and hence are of doubtful authenticity. Blakey's (3) work on the wild turkey indicates that predatory damage to wild turkeys in Missouri may result from depredations by opossums, great horned owls, and wolves, with snakes, bobcats, and possibly woodchucks as nest predators.

From the viewpoint of affording protection against predation the ideal range should be on rough and even precipitous terrain; or if flat, it should contain barriers to the free passage of man and animals such as wide streams and swamps. On range of this character all but the very youngest birds can quickly fly to a safe haven when molested by their enemies.

Losses Due to Hunting. Hunting wild turkeys is permitted in only a few states, and information on the number of birds legally shot is meager. The legal take of 500 turkeys in Missouri for 1935 represented 14 per cent of the estimated wild turkey population (*19 g.r.*). Crippling losses probably raised this figure to a total of 20 per cent. For Virginia, Mosby (22) says that the present population can be maintained if an annual take of 30 per cent is not exceeded; this figure allows for an additional estimated crippling loss of 3 per cent of the total early fall population. The illegal hunting take was estimated as 10 per cent. For 1938 and 1939 the hunting take in Pennsylvania was 6,766 and 5,191, respectively. During this same period the Pennsylvania State Game Commission released 1,954 turkeys. Eventually, when the habits and responses of the turkey are better understood, it may be possible to state with greater assurance the hunting take that a population is able to withstand, but at present it is evident only that hunting must be closely regulated if wild turkeys are to maintain their numbers or increase.

MANAGEMENT

The management of the wild turkey is as yet in a nebulous state and is quite generally based on insufficient knowledge of the pertinent facts. Intensive management measures have been local in character, and recommendations for the most part have dealt with general principles, like regulation of hunting and methods of restocking depleted ranges. The problem at present is threefold, involving (1) extension of the range, (2) the protection of existing population, and (3) increased production on both present and potential ranges. Until the wild turkey becomes more abundant,

intensive management is not practicable except perhaps on hunting preserves. The problem is complicated further by the extensive area of land required for a single unit of range. The minimum land unit for successful management is variously placed at 1,000 to 100,000 acres (4, 14, 22, 31). Mosby suggests 50,000 acres or more as a satisfactory-size unit, while Blakey believes it should cover from 20,000 to 100,000 acres. The limitation of size alone is sufficient to restrict management activities to public agencies and a special class of private owners or organizations such as hunting clubs having large tracts of land subject to control under one administration. The exception to the above statement may be found in southern Texas, where both deer and turkey hunting are handled on a leasing basis by owners of private lands (32).

Census Methods. The generally accepted turkey census method is based on the complete census as developed by Mosby and Handley (24) by which the range is carefully searched for summer broods or winter flocks. This is not always an easy task unless the range is well known, for the flocks are rarely numerous and occupy extensive territories. Mosby (23) adopted this procedure on a state-wide basis in Virginia, and Leopold and Dalke (17) have used it successfully in Missouri. This census procedure uses information obtained from game wardens, custodians of sanctuaries, gamekeepers on estates, turkey hunters, and similar sources. The county game wardens supply the names of prospects who are likely to have information about turkeys. These prospects are then notified in advance of an interview and asked to cooperate. In this way the entire turkey range is thoroughly canvassed.

In Texas a successful census of the Rio Grande turkey has been made by Goodrum (10) by counting the birds as they fly to the roost trees. This, no doubt, will work where the range and habits of the birds are well known and the trees in which they roost sufficiently separated from the surrounding cover to make observations possible.

Food and Cover Development. The problem of improving habitat conditions, particularly the development and maintenance of suitable cover, is strongly influenced by two considerations: (1) the extensive character of the area subject to treatment and (2) the fact that forested portions of the range commonly serve other uses, notably the production of wood crops and as range for livestock. Under such circumstances the application of intensive cultural measures is rarely possible or at best applicable only on a limited scale. The development of supplementary food supplies is perhaps the main exception. This practice not only is feasible but is strongly recommended.

Fortunately, recommended measures for maintaining productive turkey range conform for the most part with sound forestry practice. In fact, a forest properly managed for the sustained yield of forest products

affords a more favorable habitat than the unmanaged forest, provided the silvicultural treatments employed develop stands of the required composition. This latter point is not likely to become the subject of serious contention between the forester and the wildlife manager except perhaps locally. In most regions where wild turkeys are sufficiently abundant to warrant their consideration as game birds, the forest types best suited to turkey management are also among the most valuable for wood production. Where land is adapted to both forms of management, there is no reason why either form of land use should interfere seriously with the other.

The recommendations that follow are somewhat less intensive than methods being practiced by certain hunting clubs, but these more detailed procedures are too expensive for general application. Furthermore, many of these intensive methods have been tailored to fit local conditions. It is believed that the following recommendations lend themselves well to the general range of the wild turkey:

1. *Control of grazing.* Heavy grazing must be excluded; otherwise, food supplies for turkeys are seriously depleted. This precaution applies with particular emphasis to hogs, which consume large quantities of mast, and to cattle to a lesser degree. Light grazing by cattle is probably not detrimental and may even prove advantageous if it serves to reduce dense concentration of undergrowth. In the Edwards Plateau in Texas, Blakey (5) recommends the fencing of 100 to 500 acres on each 3,000 to 5,000 acres of range to benefit turkey production.

2. *Control of deer population.* Heavy deer populations must be guarded against for the same reason as enumerated above. This problem is not universal throughout the turkey range but is certainly true over parts of it.

3. *Control of forest composition.* By proper cultural treatment the forest cover should be maintained for the most part, though by no means exclusively, in types containing mast-producing species, such as oak and the southern pines. Stands containing pine, usually in mixture with oak, are more common along the Atlantic coast than elsewhere. This type seems as well adapted to wild turkey propagation as the more nearly pure hardwood forests farther inland.

4. *Interspersing of forest age classes.* Forests managed on a sustained-yield basis in which there is an adequate distribution of size classes are preferable to solid blocks of one age class. Clear cutting in small units and group selection systems provide more desirable forest-cover conditions than other methods of harvest, although cutting of any kind is beneficial if the age groups are well interspersed. Openings of the sort created by tree-selection and group-selection cuttings are highly desirable, in that for several years following the removal of portions of the forest canopy suitable conditions exist for the growth of herbaceous plants and fruit-producing species like grape and blackberry. Where the forested portions of the

range are broken up by agricultural land, the need for creating openings within the forest itself is somewhat less important than on extensively forested areas.

5. *Control of fire.* In all regions except the Southern Coastal Plain, lack of forest-fire control means exclusion of the turkey. The use of *controlled burning* in the pine regions of the South and its relationship to game management are discussed at length in Chap. V, Bobwhite Quail.

6. *Supplementing food supplies.* The development of supplementary food supplies should be directed mainly toward the establishment of *food patches* for winter use. Ordinarily fruit-bearing perennials are sufficiently abundant on wild turkey range to care for the needs of this bird. Where agricultural lands occur, food patches are easily developed, but elsewhere on lands principally in forest more intensive measures are required if this management practice is adopted. Quarles (25) describes a system used on a 6,000-acre hunting preserve in Maryland by which clearings were established in the forest at intervals of 2 miles and planted to food plants. Twenty-eight openings were created, each of 5 acres, occupying approximately 2 per cent of the total area on this preserve. Winter wheat, millet, buckwheat, corn, and red clover were used in each patch, each variety of grain planted on a strip 1 acre in area.

For Missouri Blakey (3) recommends winter wheat, fodder cane (probably a sorghum), Japanese millet, winter rye, and chufa. Chufa is less drought resistant than the others. Winter wheat or barley to provide *green feed* is important. Note relatively high content of this type of food in Table 67. For the southeastern wild turkey range, Stoddard (30) suggests chufa, peanuts, the sorghums, cowpeas, and brown-top millet. Oats, wheat, and rye, recommended for October planting, provide green food for winter and spring consumption. The succulence thus afforded is thought to be useful in augmenting a deficiency of water during periods of drought, and furthermore the grain is an excellent summer and fall food supplement. Varieties intended to supply grains should be selected from beardless types, the bearded types being less attractive for the reason that turkeys strip the seed directly from the head and find the beard offensive.

Food patches ordinarily provide winter food in sufficient quantity to carry the wintering population through seasons when mast is scarce; but should these sources prove inadequate, additional feeding may become necessary (26). Where local food supplies fail, turkeys may migrate to a new range. Grains, especially corn, are well suited for use as supplementary feed, and Stoddard strongly recommends peanut chips, a by-product known to the trade as "oil stock." Ramsey and Taylor (26) fed corn and milo maize satisfactorily in self-feeders protected by fenced corrals 25 feet long on a side.

When food patches must be protected from grazing animals, this can be

accomplished by fences constructed about each patch or around the entire wild turkey range where this is possible. The latter is preferable, as a fence around a food patch may keep out the turkeys as well as livestock. This situation is partially rectified if fences are built of logs, as turkeys soon learn to fly over the fence; but where wire is used, they attempt to go through rather than over it.

For developing fruit- and mast-bearing species in the pine regions of the South, Stoddard (30) recommends *controlled burning* at time intervals of 3 or 4 years. Chinquapin, ground and runner oaks, huckleberries, blueberries, and similar shrubs respond favorably to this treatment. Annual burning is more likely to reduce than to increase the rate of fruit production.

Artificial Stocking and Control of Hunting. Because large areas of inhabitable wild turkey range are devoid of turkeys and adjacent stocked areas are too distant or too thinly populated to stock such lands by natural means, the release of artificially propagated birds is likely to occupy an important place in most management projects (8). Stocking on a small scale is being practiced by several states, but all too often with indifferent results, failure being due primarily to two factors: (1) the release of birds lacking truly wild instincts and (2) inadequate provision for protection after release. Mosby's (21) recommended procedure is to release the young birds during the fall in groups of 15 to 20 in the ratio of 6 females to 4 males. Fall release is said to have a number of advantages: Natural food supplies are available in abundance at this season, and in addition the young birds appear to adapt themselves more quickly to their wild habitat than older birds.

The problem of rearing stock having a well-developed wild instinct is a very real one, which merits and is receiving intensive study. Too many released birds come from strains containing blood of domestic stock (8). Often the rearing methods are such that even birds of desired ancestry gradually develop an immunity to disturbances that is not entirely overcome following their release. Handley (11) advanced the premise that keeping turkeys in small pens produced wildness. Later work, however, brought to light the fact that isolation of pens from areas visited by humans is of more value than the size of the pens. In fact, confining birds in small pens resulted in one-third of the birds breaking their wing bones during handling, probably owing to lack of exercise of the wings in the closely confined pens. Crossing of hybrid females with wild males has been tried by several states as a means of developing wild stock. This is accomplished through the use of large breeding enclosures placed in natural wild turkey habitats, each enclosure containing 40 to 50 acres of native vegetation, undisturbed except for the fence around it. Fifteen to twenty females with plucked wing feathers are placed in the pen to breed with the wild toms that fly in from the adjacent range. Later, the enclosure is

opened, allowing the hens and their poults to disperse. In Virginia the pens are from 1 to 2 acres in size and 20 hens are placed in a pen. The eggs are collected from the nests and hatched and reared artificially (24). The value of this procedure as well as the general subject of "wildness" has been studied by Leopold (16) under Missouri conditions, and some interesting and valuable discoveries have been made. Leopold (16) concluded that the breeding of hybrid hens in open pens on wild turkey range does not always produce offspring of increasingly wild tendencies, as the males that come to the pens may also be hybrids. In comparing 15 state refuges some of which were stocked with hybrids and native stock and some with wild stock only, it was found that of five successful refuges (40 birds per township) four sustained predominantly native stock and the fifth a mixture of native and hybrids. All of the ten remaining refuges appear equally good as to suitability for wild turkeys, but all carried predominantly hybrid birds, and all were considered unsuccessful according to the measuring stick of 40 birds per square mile.

The *trapping* of turkeys has been accomplished successfully by Goodrum (10) with tentlike traps of fish net.

> The net trap is a simple affair, and it may be described as a tent 40 by 50 feet in size and made of No. 16 cord with 2-inch mesh, dyed forest green. An attendant concealed about 40 yards away releases a drop gate, or curtain, located in one end, by means of a fine wire attached to the curtain. A ¾-inch hollow iron pipe is fastened to the bottom of the net curtain as a weight.

For several days prior to actual trapping operations, yellow corn or a similar bait such as hegari should be scattered about the trap and in it. Once the birds lose their fear of the net and enter it freely, trapping can begin. Log traps were tried in Virginia but were abandoned because of interference by poachers (24). For *transporting* captured birds, Goodrum recommends a crate measuring about 32 inches long by 22 inches wide and 22 high. Each crate has two compartments and transports two birds. Wild turkeys held in crates for as long as 30 hours have shown no ill effects. Birds being handled should be grasped by the legs with one hand and supported under the breast by the other.

Stocking of suitable but unoccupied range with wild stock has been tried successfully in Wyoming as reported by Coughlin (6), who indicates that 15 wild birds moved to the Laramie Peak district in 1935 had increased to 600 birds by 1942 and have spread to 16 townships.

The problem of *protection*, though concerned in some measure with the control of grazing and predators, is primarily a matter of regulating hunting, especially illegal hunting. This entails legislation stipulating the length of open season, the allowable take, and provision for strict law enforcement. Where wild turkey populations are sparse, complete exclu-

sion of hunting may be necessary. Illegal hunting is considered by Leopold and Dalke (17) to be the most important factor limiting the increase of the wild turkey in Missouri. The most damaging form of illegal hunting is the taking of "frying-size" poults in early fall. In Virginia Mosby and Handley (24) claim that 10 per cent of the wild turkeys killed are taken illegally.

Elsewhere, even in states having better than average wild turkey populations, conditions as a whole rarely justify an open season exceeding a month or a season's take of not more than one bird per hunter. Only on hunting preserves are conditions likely to warrant larger kills. Mosby and Handley (24) question the legal restriction that limits hunting to males only. These investigators are opposed to the spring shooting of gobblers and furthermore point out that states where spring turkey shooting is allowed are losing their eastern wild turkey populations at a rapid rate. Mosby and Handley recommend that turkey hunting be allowed only during the fall and winter, and furthermore that a limit of the take to males only is not practical owing to the difficulty of distinguishing one sex from the other under hunting conditions.

In states that permit turkey hunting, *refuges* have proved successful as a management practice. In an undisturbed environment the chances of successful reproductive seasons are far greater than where hunting scatters and depletes the flocks (15, 18). To be highly effective, refuges should be no smaller than 5,000 acres and preferably four or five times that size. Leopold and Dalke (17) state that size of a refuge is not so important as are suitable topography, cover, and management. Exclusion of *all* human activity is necessary to the successful operation of a turkey refuge in Missouri.

Under Virginia conditions Mosby (22) recommends that entire counties be closed to hunting until turkey populations attain a desired density. This plan eliminates the troublesome problem of protection and administration so frequently encountered where refuges are established in smaller size units. Setting aside units as large as a county does not, however, eliminate human disturbances, which are so detrimental to successful turkey management.

A completely closed wild turkey season has been in force in Missouri since 1937. In 1931 Leopold (*65 g.r.*) estimated an average density of 1.4 square miles per bird. In 1937 Bennitt and Nagel (*19 g.r.*) determined the wild turkey population for Missouri as 2.8 square miles per bird over 9,907 square miles. An intensive inventory by Leopold and Dalke (17) in 1942 gave the turkey population as 1.6 square miles per bird for 7,000 square miles. Closing of the entire state to legal wild turkey shooting and the improvement of game-law enforcement have without question contributed to the improvement of the wild turkey population density, al-

though more accurate methods of census and other management practices may have possibly contributed to the apparent increase.

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CHAPTER XIV

AMERICAN WOODCOCK

Philohela minor (Gmelin)

GEOGRAPHICAL DISTRIBUTION

The range of the American woodcock includes the eastern part of the United States and the southern part of eastern Canada. Pettingill (9) gives the breeding range as extending as far east as Newfoundland; north to New Brunswick, southern Quebec, and southeastern Ontario; west to eastern South Dakota, eastern Nebraska and Kansas, eastern Oklahoma, Texas; and south to southern Louisiana and central Florida. It winters primarily in the south Atlantic and Gulf states as far west as Tom Green County, Texas. The northern limit of its wintering territory is southern Missouri and east to the seaboard. It migrates from south to north in the early spring and back south again in the fall after the breeding season.

In general the woodcock is a woodland bird but frequently appears in towns and even large cities where a small amount of vacant land is available with enough brush or weeds to provide a minimum of cover and where earthworms and other suitable foods are available.

MORPHOLOGY, LIFE HISTORY, AND ECOLOGY

In both morphology and habits the American woodcock is an unusual bird. Its head is too large for its body, and its eyes and bill are too large for its head. It walks with a clownlike waddle and flies with the crazy course of a ship without a rudder. Although its flesh tastes slightly like liver, it is beloved by many sportsmen for its sporting properties. It has been given a number of odd names including "golden bombshell," "timber-doodle," "bog-borer," and a host of others.

The sex of a woodcock is difficult to determine except by internal examination. As to weight of males and females, Aldous (1) says that there is little correlation between weight and sex. Of 326 birds taken in the fall during 2 years in Maine and New Brunswick the lightest, a male, weighed 4 ounces, while the heaviest was a female, weighing 9 ounces. Aldous refers to weights of 49 woodcocks from Nova Scotia, where 11 of the 49 weighed 9 ounces and one 10.5 ounces. He felt that these records substantiated the belief of sportsmen that flight or migratory birds are likely to be heavier than local birds bred in our Northeastern states. Later conclu-

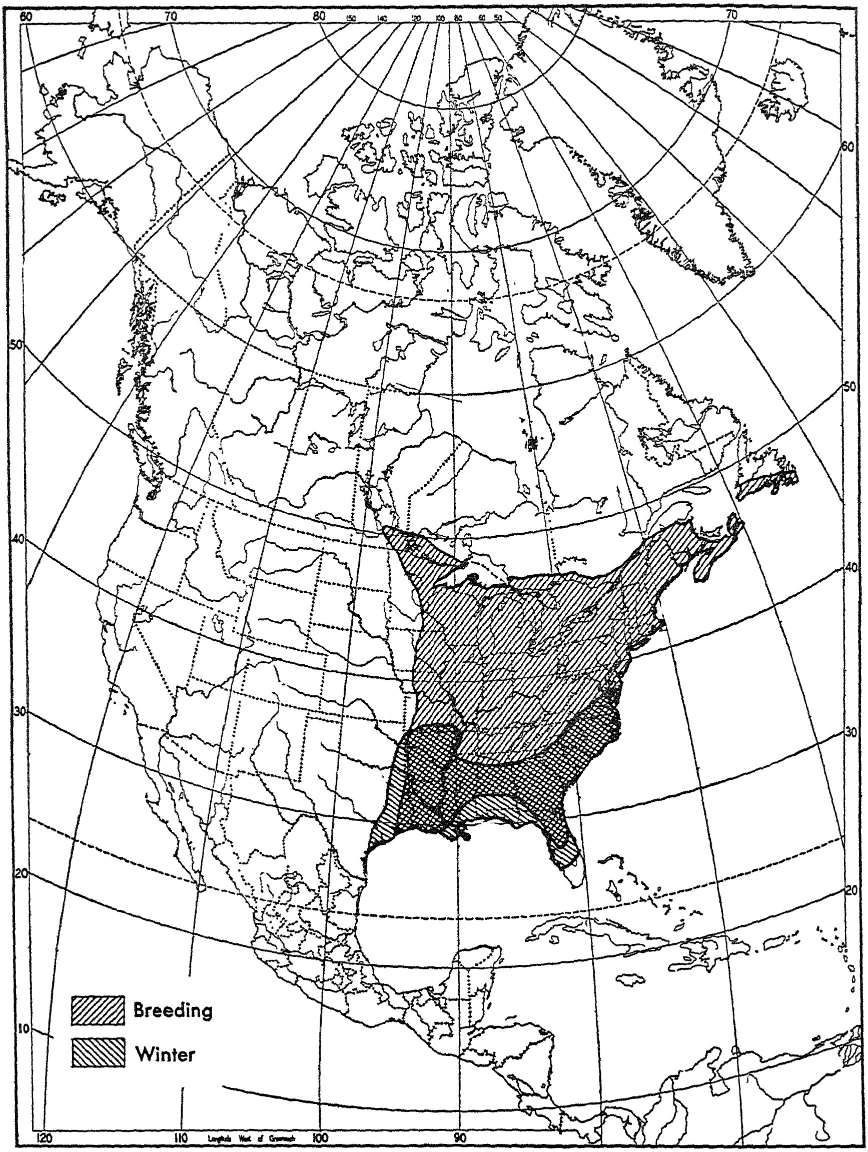

FIG. 14·1. Range of the woodcock. (*Mendall and Aldous*, 1943.)

sions by Mendall and Aldous (6) indicate that differences in weight are due to the difference in time of weighing, all birds being heavier as the season advances.

In attempting to find an external feature that would distinguish the sexes, Aldous (1) discovered a difference in the length of the bill between

male and females. A mature bird with a bill more than 72 millimeters long is likely to be a female; of those with bills over 70 millimeters in length, 95 per cent are females; birds with bills between 66 and 70 millimeters may be either sex; 95 per cent of those with bills 66 millimeters long are males; and those with bills only 64 millimeters long are almost sure to be males.

Breeding Characteristics. The mating activity of male woodcocks may start in the spring before the snow is entirely gone. The breeding activities center around the singing ground, which is usually an open area such as a field or roadway in the forest or brushland. The male establishes himself in one of these locations and from it makes his dawn and dusk flights with the apparent purpose of attracting one or more females to him. Mating presumably takes place on or near the singing ground.

The singing field varies in size and may be either large or small and regular or irregular in shape. In Pennsylvania on a dry area in Centre County in the scrub oak-pitch pine cover type, the average singing field or opening is 21 by 37 feet (11). In Maine under different cover conditions, the singing fields appear to be larger, the minimum being about 66 feet on a side (6). According to Mendall and Aldous (6), the shape of the singing field may vary from round to long and narrow, a logging road being used as a singing ground in one instance. The shortest distance between two singing fields was 210 feet, but most of them are much farther apart. The male bird defends his singing territory against other males and according to Studholme, Buele, and Norris (11) may have one or more supplementary fields from which he sings. Singing grounds are usually 200 to 250 feet apart in Pennsylvania (11).

The mating of woodcocks appears to be monogamous (6). Pettingill (9) and Studholme *et al.* (11) mention the fact that at least on occasions the woodcock apparently is polygamous, but Mendall and Aldous (6) indicate that this conclusion may be incorrect. Nesting takes place from April to the middle of June depending on the latitude in which the nest occurs. The nest is on the ground in a slight depression and often not well concealed by vegetation. In Maine, of 45 nests studied, 22 were in young mixed hardwood and softwood growth, 13 were in alders, 6 were in open hardwoods of the birch-aspen type, and 4 were in brush and cleared land (6). In Maine the nesting sites tend to be in open rather than in dense cover. The nests are not necessarily immediately adjacent to the singing grounds; the nearest of 66 nests found in Maine was 75 feet, and the farthest ¼ mile from the singing grounds. Nests may be as close together as 25 feet, although usually they are 150 feet or more apart (2).

The woodcock ordinarily lays four eggs (9), but the clutch may be three or five, the latter occurring rather rarely. Incubation begins soon after the clutch is completed, taking from 19 to 21 days to complete and being

accomplished entirely by the female (6, 9). The incubating birds are frequently "close sitters" and may allow themselves to be touched or stroked without flushing. Pettingill (9) believes that the woodcock normally brings off but one brood a season in the North but that females may renest one or even twice if the first or second nest is destroyed.

The responsibility for the care of the young rests entirely on the female. The mother and brood leave the nest soon after the eggs are hatched and

FIG. 14·2. Nesting woodcock. The color pattern of the woodcock blends well with its surroundings. (*U.S. Fish and Wildlife Service.*)

move away in search of food. If disturbed, the mother will feign injury and the chicks will "freeze" or remain perfectly quiet and as a rule escape detection. Many accounts have been written of the mother woodcock carrying its young between its feet or thighs to protect it from danger (7). Pettingill believes that this may happen not through the instinct of the female but through the peculiar position of the young while being brooded and at the time when the brood is disturbed. Thus, a young bird may accidentally be carried by the mother for considerable distance. It is not known whether a chick dropped by the mother while in flight gets back to the others or is abandoned.

Movements. It is generally believed that woodcocks do not change their locations to any marked degree from the vicinity of the nesting and breeding ground during the summer or until the migratory movements begin in the fall.

Banding returns in Maine showed that two birds of a brood banded in Baring township were shot in the same locality Oct. 27 and 29 of the same year. These birds at 5½ months of age were as heavy as adult birds and resembled them in every way. It is likely, however, that as the summer advances and food becomes scarce in one type of habitat, the birds move to a location where food is more plentiful. Thus, Pettingill (9) quotes Forbush and others as finding the timber doodle on lawns and in corn and asparagus fields as the summer advances.

The woodcock is generally considered a migratory species, but apparently not all of the individuals migrate to the same degree. The migration is controlled largely by weather conditions in relation to the food supply. Sometimes woodcock are caught by cold weather which freezes the ground and locks up the food supply. At such times the birds may be seen in unusual places, as along the sunny side of buildings, on lawns in cities, and around springs where the ground remains unfrozen and food is available.

The wintering grounds of woodcocks are in the states bordering the Atlantic Ocean and the Gulf of Mexico. In addition to this territory Arkansas and eastern Oklahoma also have wintering birds. The tip of Florida does not seem to hold any attraction for woodcocks, but central Mississippi and western Alabama are localities of exceedingly heavy winter occupancy.

Woodcocks begin their migration north in the spring as soon as cold weather begins to moderate and as soon as food becomes available. The first appearance of woodcock migrating from the South into Massachusetts is reported as the last week in February during an early season (3), and the birds may be found almost anywhere in New England during March and early April. Mendall and Aldous (6) express the belief, however, that woodcock seen as far north as New England during February may be birds that have wintered near by.

The fall flights southward begin as soon as the ground freezes in the northern breeding range or when storms drive the birds out and snow covers the food supply. Some woodcock, however, may move northward from their breeding grounds before starting south in the fall (6). In central New England this occurs in mid-October to mid-November. Pettingill (9) lists the average date of the last woodcock seen at Windsor and Rutland, Vt., as Oct. 28 and at Ithaca, N.Y., as Nov. 5. Some stragglers are occasionally found along the Maine coast as late as Thanksgiving Day. Migratory flights are supposed to be made mostly at night.

Cover Requirements. Some reference has already been made to the cover requirements of woodcocks. In general, the bird is a woods inhabitant, although the definition of woods may be broadly interpreted as including the pitch pine-scrub oak herbaceous growth as found in the barrens

of Centre County, Pennsylvania, deep hardwood cover, alder runs, and even vacant lots on the outskirts of cities with some brushy and herbaceous cover. Openings for singing grounds seem to be necessary but, as already mentioned, may vary considerably in size and shape. Nesting cover may also vary in composition and density. In Maine during the period of 1938–1942, 44 per cent of the nests were found in birch-aspen-spruce-fir types, 26 per cent in alder or alder and willow cover, 21 per cent in birch-aspen or birch-aspen-maple types, and the remaining 9 per cent in brushland, blueberries, and cleared land (6). During the molt in late summer woodcocks seek seclusion in protective cover, which may be found along the shores of ponds or watercourses where the moisture keeps the vegetation lush and dense or on the hillsides where herbs and shrubby materials like berry bushes have reached the season's maximum growth. Forbush (*41 g.r.*) speaks of the woodcock's being found in the fall in fields of corn, strawberry beds, and potato fields.

In the South, according to Forbush (*41 g.r.*), the birds assemble in the hills and swamps of the coastal regions. When the swamps are flooded or dried out, the birds concentrate in the few places where food is available. During the hunting season in the fall woodcocks are sought by hunters in the alder runs or in any low swampy cover. Selection of these types is probably made because of the presence of food as well as because of the protective nature of the cover.

Food. The food of woodcocks is almost entirely animal material, and the bulk of this consists of earthworms.

The analyses of 261 woodcock stomachs examined by Sperry (10) covering 10 months of the year and 16 states, the District of Columbia, and three Canadian provinces give a broad general picture of the foods eaten by woodcock. Table 68 that follows is taken from *Wildlife Research Bulletin* 1 of the Bureau of the Biological Survey, U.S. Department of the Interior.

TABLE 68. FOOD BY VOLUME OF 261 AMERICAN WOODCOCKS IN THE UNITED STATES AND CANADA (10)

Food	Per Cent by Volume		
Animal food			89.46
Earthworms		67.81	
Insects		18.31	
Diptera	6.85		
Coleoptera	6.18		
Lepidoptera	3.29		
Other insects	1.99		
Other animal food		3.34	
Plant food			10.54

The plant food consists of plant fibers, bark, leaves, and seeds. The seeds include sedges, violets, alder, raspberries and blackberries, ragweed,

bedstraw, smartweed, elder, panicums, and pigeon grass. Leaves of common fern had been eaten by a bird shot on Martha's Vineyard in October. Cottam (4) states that woodcocks were seen to take cracked corn in New Jersey along with a covey of bobwhite quail during a time when an unusually hard freeze prevented them from obtaining their normal food.

Spring and summer foods as given by Mendall and Aldous (6) are 94.15 per cent animal materials and 5.85 per cent vegetable foods.

The fall food of woodcocks is indicated by the following percentages of food found in 55 stomachs collected during the fall hunting season in Maine (1):

	Per Cent
Earthworms	87.40
Beetles (*Coleoptera*)	3.75
Flies (*Diptera*)	1.37
Miscellaneous animal matter	3.54
Rubus (seeds)	2.20
Miscellaneous vegetable matter	1.74

Aldous indicates that some of the vegetable food found in the stomachs may be ingested with the earthworms, which are known to feed on vegetable detritis.

MORTALITY

While the woodcock is by nature endowed with many properties favorable to its survival, it is not very adaptable to overcoming unusual hazards that man has introduced. Muck land, which was formerly good woodcock cover, has been cleared and thus has become unsuited to use by woodcocks.

Hunting is a deadly factor on all parts of the range. Mendall and Aldous (6) estimate the annual kill as more than 250,000 birds, with the states having the highest average annual kill listed as follows:

Michigan	51,737
Pennsylvania	42,091
New York	40,555
Maine	37,000

Power and communication wires have introduced a migration hazard along the woodcock's flight lanes. Unseasonably cold weather or deep snow on any of its range introduces a factor that may affect both the survival of the birds and their ability to reproduce abundantly. Pettingill (9) cites cases where various kinds of hawks were found feeding on woodcock remains, but little evidence is available that would indicate heavy or persistent predation by either mammalian or avian carnivores. Concerning losses of woodcock Aldous (1) says:

From data available it seems likely that a comparatively large number of birds are killed or badly injured by flying into obstructions, chiefly telephone and electric-light wires. Fire is a most important factor in woodcock losses in eastern Maine particularly during the nesting season, as it is then that a great deal of blueberry land is annually burned over. These fires, besides burning the vegetation on the open berry lands, frequently get out of control and destroy the cover on adjoining lands, and it is there that many woodcocks are driven from their nests.

During the woodcock study in Maine, Mendall and Aldous (6) found both cats and dogs destructive to both adult and young woodcock. These investigators cite eight cases of known destruction of woodcocks by cats and three by dogs. Fourteen other predatory species were listed, but with the exception of the black snake the amount of loss was negligible.

MANAGEMENT

Census. The only cheap and practical census of woodcock appears to be the count of males on the singing grounds. This can be accomplished by game wardens or others familiar with woodcock biology and the nature of the cover on the range of the woodcock. The singing-ground-census method consists of observing the singing males during evening and early morning and the calculation of the total breeding population by doubling the number of males observed, since Mendall and Aldous (6) indicate that the sexes appear to be equal. In connection with this, a count of the average number of young in a brood may be determined by the use of a good bird dog (1, 6). A dog was used in Maine for 15 days following the hatching period to locate the young for banding.

The Maine study revealed that one of the limiting factors on the breeding range was a lack of openings used by the singing males for courtship grounds. Since 1937 experiments have been going on to create new singing grounds by the clearing of the vegetation in the vicinity of good nesting territory. Indications are that openings so created are successful in attracting the breeding birds, but so far no evidence is at hand to indicate whether this increases the number of birds in a given area or merely represents a shift of breeding birds to more desirable courtship territory. Mendall and Aldous (6) give the optimum number of singing grounds on good range as one for each 6 or 7 acres of cover.

Control of Cover. Fisher (5) contended that the woodcock reached its peak of abundance in New England during the period from 1870 to 1900, when the reversion of old abandoned fields to forests was most rapid. Then, while maturing white pine wood lots occupied a large part of the area, woodcock populations temporarily declined. This was, of course, largely due to the lack of earthworms in the typical soils of such old-field pine stands. Following cutting of the pine stands, hardwoods, which had developed as advance growth, took possession of these areas and the soil profiles changed

in a period of about 15 years, so that earthworms were again to be found in numbers. During his intimate experience of 27 years as director of the Harvard Forest, Fisher observed the return and nesting of woodcock in these young hardwood stands following pine cuttings. The relation of these observations to silvicultural control of woodcock populations is obvious. Any system of forest management that periodically creates young, mixed stands of hardwoods on the better soils provides good feeding grounds as well as good cover for either resident or flight birds. Mendall and Aldous (6) state that both heavy timber cuttings and fires seem to create soil conditions favorable to earthworms. In so far as the use of fire is concerned, this is true, however, only in the case of coniferous forest types.

Clear cutting of timber and selective cutting, particularly with a reduction of conifer species, will also improve woodcock cover conditions.

Miscellaneous Management Procedures. Other measures suggested by Pettingill (9) for the better management of the woodcock are as follows:

1. *Hunting.* Restrict the hunting season to 2 weeks during the time when the migration wave is at its height. Restrict the hunting take to two birds per hunter a day. Close hunting areas where the birds concentrate along the migration route. Close the season entirely following years when catastrophes on the wintering grounds have reduced the birds below the normal numbers. Abolish hunting of woodcock in those areas in the states along the south Atlantic coast and the Gulf of Mexico where they concentrate during the winter.

2. *Control of fire.* On the northern breeding range carry on burning of blueberry lands in the fall after the breeding season is past and at a time when the spread of fires to adjacent woodcock territory is least likely.

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Section III

WILDERNESS WILDLIFE

CHAPTER XV

MANAGEMENT OF WILDERNESS AREAS

Four hundred years of occupation and use have changed a large part of the North American continent from a primitive wilderness to a despoiled and devastated landscape of cutover and burned-over forests, eroded agricultural lands, and polluted streams and lakes. The next decade with its development of gasoline-driven conveyances including the caterpillar tractor, the airplane, and the helicopter may see the use of what is now "back country" intensified to a marked degree.

Considerable back country still exists in various parts of the United States, Canada, Alaska, and Mexico, where remnants of rare and valuable flora and fauna still occur. With a proper understanding on the part of the general public of the need to keep some of these areas inviolate, it still may be possible to preserve both the land and some of the organic resources of these primitive wilderness areas for future generations to study and enjoy.

There is a greater need for research on the primitive landscape than most people appreciate. As pointed out by Leopold (3), recognition of land sickness, which we see all around us in the form of eroded hillsides, silted reservoirs, and elk and deer "irruptions," is no assurance that a cure has been found for these maladies. Only a careful study of a healthy land as found in an unspoiled wilderness will show the way to keep other similar land areas healthy. If this is true, some provision must be made to set aside a few samples of unspoiled land to study; otherwise, at some future date the nations of the North American continent may find themselves in the same predicament as do the peoples of China and India today.

People have been able to adjust themselves to their environment so that neither the environment nor the people occupying it are endangered. This is well demonstrated on opposite sides of the world, in northeast Europe (3) and in Korea.[1] Of Korea, Tosi says:

[1] Personal communication from Joseph Tosi, Dec. 15, 1945.

The steep slopes are reserved to timber extensively and exclusively. All the moisture from spring runoff is retained, settling into these rich terrace strips. The very closeness that the people have with their environment makes them seem a part of it rather than apart from the harmony of all living things.

In a text on wildlife management, an extensive discussion of the sociological values of any class of land would be out of place. Therefore, the remainder of this chapter will be devoted to a discussion of the use and management of wild areas and the characteristics of the animals that occupy them.

Recommendations for the management of wilderness areas is contained in the platform of the Wilderness Society which is quoted in part from "Forest Outings" (6) in relation to a management policy for a primeval area.

Though in general a hands-off policy will best care for a primeval area, a *management policy to retain the primeval is necessary.* It is still a question as to how far we can go in providing artificial protection against fire. Fire control nearly always demands additional trails, telephone lines, and lookout towers. The provision of this equipment furnishes a means of fire protection but at the same time brings in man-made control as against natural control.

Systematic and regular airplane fire patrols equipped with two-way radio should eliminate the need for permanent forest-fire control structures such as lookout towers and manning them with lookout firemen, both of which are so disturbing in primeval areas. Although the presence of a plane may seem unwarranted to wilderness travelers, its effect on the landscape is not so objectionable or so lasting as the results of a disastrous forest fire.

Leopold *(66 g.r.)* defines wilderness game as "species harmful to or harmed by economic land uses and therefore suitable for preservation only in public game reservations or in public wilderness areas." In this category may be included moose, American elk or wapiti, bison, grizzly bear, mountain lion, woodland caribou, mountain sheep, mountain goats, marten, fisher, and wolverine, as well as numerous nongame and nonfur animals including the ivory-billed woodpecker and California condor and many smaller animals.

Much of the land on which remnant populations of the animals listed above are now found is included in lands administered by the Federal Forest and Federal Park Services. The U.S. Forest Service has set aside suitable areas under different designations, a summary of which follows.

WILDERNESS AREAS IN NATIONAL FORESTS

Wilderness areas are found in the National Forests under a number of designations. These areas differ somewhat in size and the conditions under which each is managed, but in most of them the highest use is *not timber*

production as contrasted to other parts of the surrounding National Forest lands.

The designations and definitions used here are taken from releases from the office of the forester, U.S. Forest Service, Washington, D.C., dated Dec. 31, 1942.

Natural Areas. Natural areas are lands set aside to be permanently preserved in an unmodified condition and to be representative of the virgin growth of each forest or range type within each region in so far as they occur within the National Forest, to the end that its characteristic plant and animal life and soil conditions and the factors influencing its biological complex shall continue to be available for purposes of scientific study, research, and education.

There are 54 natural areas in the National Forests, and these contain a total of 62,190.65 acres. The largest single natural area embraces 10 square miles of land and is in the Chippewa National Forest in Minnesota.

Roadless Areas. Roadless areas are lands in National Forests that would be suitable for a wilderness designation except that the economic values involved are too great or other considerations make such a designation impracticable. It still may be desirable and feasible, however, to exclude permanent roads from such areas, thus preserving many of the wilderness values but allowing utilization of the timber or other resources by means of temporary roads unsuitable for ordinary motor travel.

Two roadless areas containing a gross area of 1,036,550 areas have been set aside in the Superior National Forest in Minnesota.

Vanishing-species Areas. Vanishing-species areas are lands set aside for the perpetuation and protection of rare or vanishing species of plants or animals.

Four vanishing-species areas have been set aside and contain a total of 17,990 acres.

Primitive Areas. Primitive areas are lands characterized by primitive conditions of environment, transportation, habitation, and subsistence.

Sixty-one primitive areas have been set aside and contain a gross area of 11,516,178 acres. The largest one contains 1,872,295 acres.

Wilderness Areas. A wilderness area is land characterized by primitive conditions of transportation and habitation. It contains no provision for motorized transportation and excludes hotels, resorts, summer homes, and commercial logging. The minimum size that is recognized as a forest wilderness area is 100,000 acres. The boundaries of a wilderness area are always located at least ½ mile back from any route for motorized transportation. There are four wilderness areas on six National Forests in three states, as of Dec. 31, 1942.

Wild Areas. A wild area has the same characteristics as a wilderness area but is less than 100,000 acres in extent but contains at least 5,000 acres.

FUNDAMENTALS OF THE WILDERNESS CONCEPT

The fundmental idea of the need and value of wilderness areas is well expressed in the platform of the Wilderness Society in 11 statements of objectives as follows (8):

1. That the wilderness (the environment of solitude) is a natural mental resource having the same basic relation to man's ultimate thought and culture as coal, timber, and other physical resources have to his material needs.

2. That the use of this resource should be considered a public utility and therefore its commercialization should not be tolerated.

3. That the time has come, with the brutalizing pressure of a spreading metropolitan civilization, to recognize wilderness environment as a human need rather than a luxury and plaything.

4. That this need is being sacrificed to the mechanical invasion in its various killing forms.

5. That scenery and solitude are intrinsically separate things, that the motorist is entitled to his full share of scenery, but that a motorway and solitude together constitute a contradiction.

6. That outing areas in which people may enjoy the nonprimitive forest are highly desirable for many pent-up city people who have no desire for solitude but that such areas should not be confused in mental conception or administration with those reserved for the wilderness.

7. That since primeval succession can never return once continuity has been severed, it is manifestly the duty of this generation to preserve under scientific care, for the observation, study, and appreciation of generations to come, as many, as large, and as varied examples of the remaining primitive as possible.

8. That the wilderness remaining in America has shrunk to such a small remnant of the country's total territory, that whatever area does remain is all-precious and its preservation is a vital need.

9. That encroachment upon our remnant of American wilderness in any one locality is an attack upon the whole and creates an issue of national moment and not for local action alone.

10. That since the invasion of wilderness areas is generally boosted by powerful, country-wide organizations, it is essential that individuals and groups who desire to preserve the wilderness must unite in a country-wide defense.

11. That the means of achieving our objectives should be positive and creative as well as merely defensive and hence that a long-range plan should be evolved toward bringing forth its mental and ultimate human uses.

Isaiah Bowman (8) has expressed the problem in relation to the values of natural resources very clearly as follows:

The conservation of our natural resources . . . is a problem in social ethics. . . . I emphasize the careful location of conservation in the American scheme of things because of the great number of techniques . . . among which it is easy to get lost. . . . The gap is so wide between the forested watershed above and the farm

below that cause and effect are less obvious. It is the social ethic that lags behind. Time is wasted on postmasterships that should be spent in quickening the national conscience about the waste of things we shall never again recover, like the forty-acre farm that goes down the Mississippi every minute. . . . The goal [of democracy] is a controlling majority doing the right thing as a result of intelligent forces at work within, rather than by arbitrary force imposed from without. Conservation is therefore educational. . . . But I would warn you that the educational task is partly an emotional task as well as a task in reason and persuasion. Some one must be on fire about it.

LIFE HISTORIES AND ECOLOGY OF SOME WILDERNESS WILDLIFE

Life histories and environmental relationships of the American elk, gray wolf, moose, and woodland caribou will be discussed in some detail in the chapters under *Wilderness Wildlife*. Briefer life-history notes on the bighorn sheep, grizzly bear, pronghorn antelope, and Rocky Mountain goat also will be included.

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CHAPTER XVI

AMERICAN ELK

Cervus canadensis [1]

GEOGRAPHICAL DISTRIBUTION

The American elk or wapiti is a majestic animal that was formerly found in wooded parts of North America south of the coniferous forest belt. Its flesh and hide were used to advantage by the early explorer and trapper for food and clothing, the latter particularly where durable leather was needed. The American elk passed from its eastern range at an early date, probably from natural causes (16, 18), and the herds in the West shrank under the impact of ranching and use of the land for other agricultural purposes. Several hundred thousand pounds of elk meat are harvested each year, but in general the relations of human beings and elk are in a turmoil of discord due to overpopulated ranges and conflict of the elk with property of ranchers and farmers on the winter range grounds.

At present the principal herds of elk are on the western ranges, in the Yellowstone National Park and on public lands in Arizona, New Mexico, California, Utah, Colorado, Montana, Idaho, South Dakota, Washington, and western Canada. Scattered herds may be found in several of the states east of the Mississippi river, including Wisconsin, Michigan (18, 23), Pennsylvania (8), Virginia (2), and New Hampshire (22). The 1940 big-game inventory by the U.S. Fish and Wildlife Service gave the total number of elk in the United States as 207,769. Elk are in no immediate danger of extirpation.

ANATOMY, LIFE HISTORY, AND ECOLOGY

The size of the elk is intermediate between that of the deer and the moose. A 3-year-old male weighs about 500 pounds, while older males may weigh twice that much. The color of the wapiti's pelage varies with the age of the animal, the time of year, and the locality. In general the color is gray to brown, being lighter on the ventral side and darker above. The newly born calf is a light brown with cream spots. Only the males have antlers, which are shed once a year. Antler development is apparent in the males shortly after birth as small buttonlike processes under the skin,

[1] The American elk, genus *Cervus*, is represented by five species in North America (*78 g.r.*).

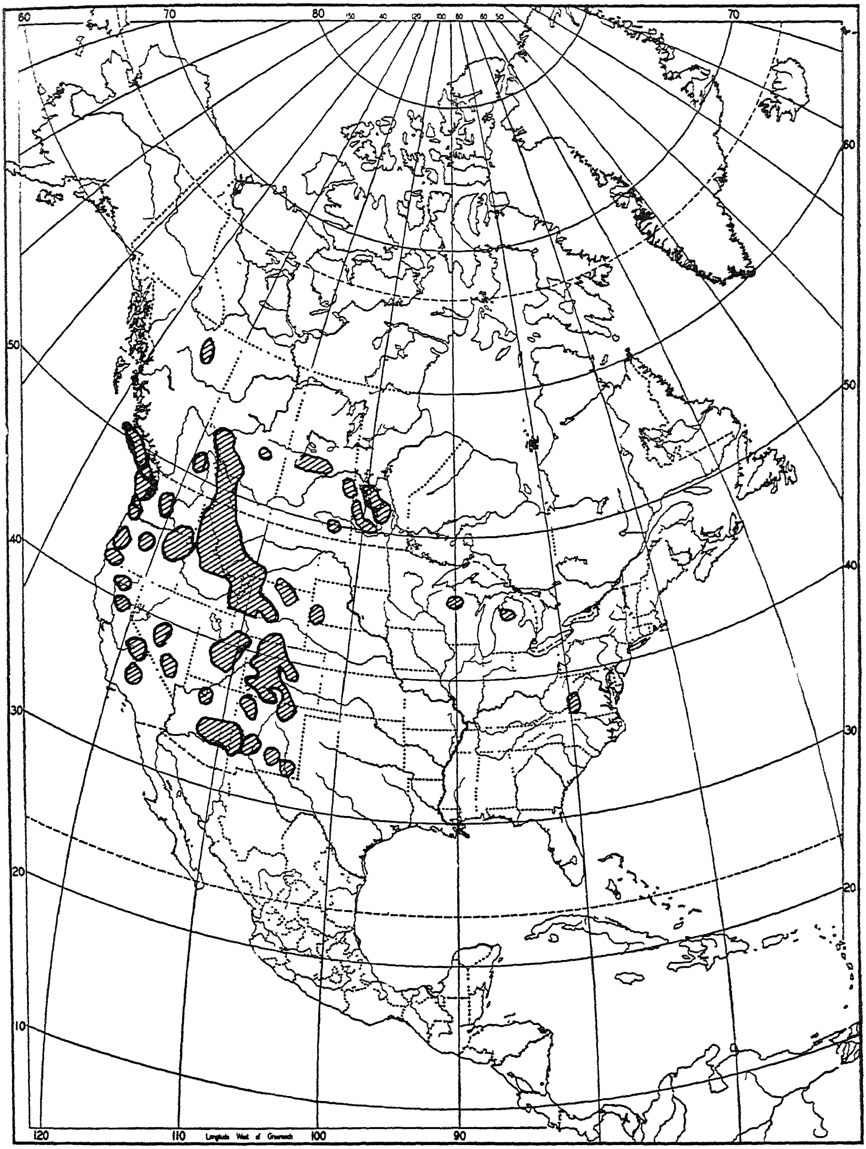

FIG. 16·1. Range of American elk. (*By U.S. Fish and Wildlife Service*, 1943, *and C. H. D. Clarke, Toronto, Canada*, 1941.)

but these do not break the skin until the beginning of the second year, when spikelike antlers appear. These spikes are shed during the winter period of the second year and are followed by a crotched horn the third season. When the male is 4 years old, branching antlers appear that have four or

five points (9) and are shed each season between January and April. According to Hollister (12) the dates when the antlers are shed by the elk in the National Zoological Park at Washington occur during the first part of March. Skinner (20) gives the season for shedding of antlers for the Yellowstone Park elk as Feb. 28 to May 4, but antlers are shed earlier if the vitality of the animal is low. Antler development reaches its height during the seventh year of the animal's age and then declines (9).

Breeding Characteristics. Female elk are capable of breeding at 21 months of age, and males at 2 or 3 years, according to Mills (13) and Green (9). Strong, virile males begin to gather together a harem of females in the early fall during August or September and fight off any attempt on the part of less dominant males to steal members of their harem. These harems may number from three to fifteen females depending on the number of strong, active males in the herd (9, 19). The average number in a harem on the Riding Mountain Preserve in Manitoba during 1930–1932 was eight. Two-year-old males are believed to be capable of breeding but seldom get the chance owing to the protection given the harem by stronger individuals. During this period yearling calves attempt to stay with the mothers but are jostled around considerably. Green (9) doubts if a true oestrum exists in female elk but states as his belief that the female reproductive organs are functional, with no accompanying reproductive urge. Bugling, or the onset of breeding, in the male may begin as early as August and last to about Nov. 1. Mills (13) found that 74 per cent of 1,129 female Yellowstone Park elk that he examined were pregnant, with the remaining 26 per cent barren because of age, disease, or other causes. Young (24) reported almost identical conditions in relation to elk in Idaho. The gestation period is 8 to 8½ months, and the calves may be born any time between mid-May and mid-June. One calf for each female is the rule, but Green (9) says that twins are a possibility. This is verified by Olson (14), who found two sets of twins in an examination of 175 pregnant cows. Presumably at birth the sexes are equal, but there is little factual evidence on this point (4). Schwartz (19) gives the ratio of mature bulls to total elk populations as 10 to 20 per cent.

After birth, the calf is left hidden for several days and then follows its mother and is protected by her. The young depends on the mother's milk for a period of 4 to 6 weeks or even longer (19, 25) and may suckle until September, but during the latter part of the summer it does a good deal of grazing. Olson (15) gives the composition of a normal elk herd as follows:

	Per Cent
Mature animals	48
Two-year-olds	14
Yearlings	17
Calves	21
Total	100

Under favorable conditions the increase at the time of calving may be 20 to 25 per cent of the total herd

Movements and Herding Characteristics. Elk are restless creatures, due in part, no doubt, to the disadvantages of extreme size and also to the need for a large increment of food for daily maintenance. Resident elk are nontransitory in their habits and move only in relation to available food and external disturbances (18, 19). Migratory elk move to different elevations during the various seasons because of the availability of feed at different times of the year. Where the terrain is rough, these animals remain in the lowlands during the winter months and move up hill in the spring, usually following the watercourses as the snow recedes. The males usually precede the females, and some of the herd may remain at high levels even when the snow becomes deep. Schwartz (19) refers to a belled female that migrated 20 to 30 miles each season, coming to the same feeding grounds for the winter periods. On flatlands these yearly movements are less pronounced.

Daily movements vary with the time of year, sex, and availability of food and water.

Daily movements of the Roosevelt elk follow a pattern of resting, feeding, and watering during different times of the day and night. They feed on the bottom lands early in the morning and gradually work their way up the hillsides as the day advances, bedding down during the middle of the day. Schwartz (19) refers to the location of the midday rest as sometimes being on river bars because of the relief it gives the elk from insects. Feeding is resumed in the afternoon in a downhill direction and continues until after dark. During stormy weather elk seek shelter behind ledges or in heavy timber.

Elk are gregarious by nature and depend on a leader in their various group activities. During the breeding season a bull leads the group, but during the remainder of the year one of the cows acts as leader; variations from this may occur, however, during different times of the year. During the calving season the pregnant cows separate from the herd to give birth to their young. Just prior to the rut, elk congregate in large bands, sometimes several hundred in one band, and after the rutting period older males separate from the bands and may remain at higher elevations than the majority of the herd. These bulls may sometimes band together according to Schwartz (19).

Cover Requirements. Western elk alternate between open meadows, brushy undergrowth, and mature timber, depending on the season. Eastern herds seem to do quite well in brushlands with a scattering of openings and remnants of timber of older age classes. Likewise the interspersion of cover and open lands may be almost any combination, provided enough browse remains above the snow to provide food during the winter season and if sufficient shelter from winds and stormy weather is available. Apparently elk are not so shy as moose and will go out into open lands more freely.

Food. Much of the literature on elk during the past 30 years has been in relation to a shortage of winter food. Records of loss of elk by starvation in the Eastern part of the United States goes back to the eighteenth century, when die-offs were extensive during 1705 and 1755 (16). Where elk are restricted on winter range not only loss of the animal occurs but also damage to fences, loss of forage for domestic stock, and damage to range plants and orchard trees.

FIG. 16·2. Aspen range in Colorado. Aspen is the predominant hardwood tree of the western forests. This stand has an excellent ground cover of range plants. Much of the range used by elk and deer in the western part of the United States is not in so good condition as this. (*U.S. Forest Service.*)

Summer food is ordinarily ample, so that this phase of the food problem can be dismissed with the brief statement that it consists of grass and other herbaceous and succulent plants as well as some browse materials (25). Under such conditions as prevail in the Yellowstone National Park region, Grimm (10) states that an elk needs 0.5 acre per month for 6 months during the winter season, or 3 forage acres per winter period per animal to carry it on a sustained range basis. After examination of nearly 150,000 acres of range he concluded that it would carry 7,756 elk if no other browsing animals were present, or slightly more than 7,000 elk together with 817 deer, 175 bighorns, and 245 bison.

For Yellowstone Park elk, Skinner (21) gives a food list of 12 species

for the winter period of January, February, and March. This list includes the following: rabbit bush, tumbleweed, wild-rye grass, black sage, aspen, cottonwood, Douglas fir, limber pine, red cedar, prickly pear, birch, and willow shoots.

In the Blue Mountains of Oregon, Cliff (*20 Deer*) states that bitterbrush, snowbrush, mountain mahogany, and western juniper are preferred winter elk foods; and where these species are in vigorous condition, the range is not overbrowsed. Cliff also lists six other important winter browse plants. On a range where both elk and mule deer are present, he states that the deer will be gradually crowded out as a result of the use of range plants by elk if the range is overcrowded.

Winter food of the Roosevelt elk of the Olympic Peninsula of Washington consists of approximately 20 species of shrubs and herbaceous plants. The key winter woody plant is vine maple (*Acer circinatum*) according to Schwartz (19), although the stomach analysis showed western hemlock (*Tsuga heterophylla*) in the greatest volume for the limited number of stomachs examined. Estimates of range forage on the eastern Washington and Oregon elk ranges are calculated as 1,424 pounds green weight per acre, of which elk used 14 per cent, or 193.2 pounds per acre (17).

On the basis of the analyses of 53 elk stomachs taken on the National Forests of Region 1 for the winter period, it was found that the diet by volume consisted of 11.75 per cent conifers, 15.46 per cent shrubs, 64.97 per cent grasses and grasslike plants, 2.35 per cent weeds, and 5.25 per cent mosses and lichens (7).[1]

The food of elk in Virginia, as indicated by stomach analysis of animals taken in November, showed 26 per cent of the food to be grasses, an additional 24 per cent New Jersey tea and galax, the remaining 50 per cent being wintergreen, oaks of various kinds, blueberries, huckleberries, gill fungi, and miscellaneous twigs, leaves, and woody tissue (2).

Water and Minerals. Leopold (*66 g.r.*) believes that elk can subsist on succulence alone without water but that cows tend to seek water daily during the calving season and to drink daily where water is available. He indicates that succulence alone constitutes marginal range and that optimum range has drinking water.

Elk on different parts of the Olympic Peninsula in Washington differ in their reaction to salt licks. Those on the ocean side of the range apparently supply their mineral needs through plant foods alone; those on the east slopes use salt licks (19).

The conclusions of Young and Robinette (25) are that elk need minerals when feeding on spring vegetation and the demand is greatest from early July to early August. These animals seek minerals in locations where

[1] Total percentage does not equal 100. Data are given as originally published.

former deposits of salt have left traces of this mineral in the soil or at natural salt deposits. Where salt is present, the soil will be pawed and eaten. Under Idaho conditions elk travel 4 and 5 miles to salt areas. Young and Robinette (25) state that the location of salt has little influence on the distribution of elk but that an abundant supply of salt on the summer range will ensure earlier dispersal from the winter to the summer ranges and will help to ensure a healthier elk herd.

Population Density. The determination of the population density of a migratory species is a difficult task because of the tendency of the animals to spread out over wide areas during the summer period. Thus, the elk on the National Forests of Region 1 have a summer range of 26 million acres and a winter range during mild winters of 18 per cent of this amount and 13 per cent of it during severe winters (6). On the basis of the above figures the total area of year-round range is slightly more than a square mile to one elk. This, of course, does not indicate how much range outside the National Forests is used. Later estimates of the elk in Region 1 give the number as slightly higher, or 44,000 [1] on 27,247,427 [2] acres.

MORTALITY

The degree of mortality of elk outside of those taken by man appears to be greatly influenced by the effect civilization has had on the range. Population numbers that are beyond the carrying capacity of the winter range have frequently resulted because of the killing of the predators of elk by man and the shrinkage of the winter range because of its use for agriculture. Winter feeding has often been necessary, with its related bad effects. The adverse results of man's activities have started a whole series of mortality effects, including starvation, abortion, and other fatal results.

Quantitative data on the losses of elk by predators are meager. Henderson (11) found the remains of elk in only 92 coyotes' stomachs out of a total of 96,169 stomachs examined between 1919 and 1928. This incidence, even though each was the direct result of predation, would seem small, but the question arises as to whether the source of elk flesh was from animals that died directly as the effect of predation or from other causes. Young and Robinette (25), however, maintain that the coyote is a serious predator of fawns and elk calves in the Selway Game Preserve in Idaho. As proof that coyotes prey on elk young in Canada, Green (9) records a case where he saw brush wolves kill an elk calf, and found 17 kills that showed signs of having been made by coyotes. All these kills occurred in May and June during the calving season.

[1] From estimate of big game on National Forests as of Dec. 31, 1943, U.S. Fish and Wildlife Service.

[2] From National Forest Areas, June 30, 1943, U.S. Department of Agriculture, Forest Service.

MANAGEMENT

Management of elk consists primarily of two operations: (1) a yearly census of the elk and (2) the orderly removal of surplus stock.

Census Methods. The process of censusing elk by direct enumeration has been in practice in the Yellowstone National Park since 1912 (3). This is described by Cahalane (3) as the process of counting elk on the winter range just previous to the spring breakup. According to Cahalane, the proper time to census elk is before the snow begins to melt, in order to make the count at a time when the animals are concentrated to the greatest degree. The count is made on the same day or two consecutive days by census parties on skis, snowshoes, or horseback. Previous to the census the range is broken up into natural units, each small enough to be covered by a party of two to four men. All units are counted on the same day to prevent different crews from counting the same animals twice. Careful instructions are issued regarding the method of counting and limits of the area to be covered by each crew. Weather is an important factor in the count, as visibility must be good and snow of suitable depth. The principal errors occur when animals are counted twice in different parts of the range. Careful consideration must be given as to whether or not all elk are in the units being censused and all parts of each counting unit have been covered. Cahalane does not believe that the use of the airplane for censusing is sufficiently more accurate as compared with the count by ground crews to justify its use.

Removal. The only practical method of removing large numbers of surplus elk is by hunting. When the elk range has reached its carrying capacity, the open season should be adjusted to remove the surplus. Child (5) describes the method used for removing 3,000 head of elk from the northern herd of Yellowstone National Park during the year 1934–1935 by an open season of about 4 months. The extension of the open season beyond the normal 1 or 2 months' period was made possible by a provision in the state law that allows the Montana Fish and Game Commission to open or close the season on 5 days' notice. By extending the season and by additional trapping and slaughtering of elk in the park, together with losses through accidents, the taking of 3,265 elk was accomplished. States with elk herds will sooner or later be confronted with the problem of surpluses and should therefore initiate plans to educate the public to the need of a legal harvest as a sensible management procedure.

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CHAPTER XVII

BIGHORN SHEEP

Ovis canadensis [1]

GEOGRAPHICAL DISTRIBUTION

Bighorn sheep formerly ranged most of the mountainous areas in the Western part of North America except those near the Pacific coast. As with many other species of wilderness wildlife, civilization has driven these sheep into the most inaccessible portions of their range. Dall or white sheep are found in the Northern ranges, while the Rocky Mountain bighorn, which is larger in size, occurs further to the south. The desert bighorn, smaller in size than either of these forms, occupies a range still farther south in the mountains of Nevada, California, Arizona, New Mexico, Texas, and Mexico.

These animals are picturesque in both form and habits, adding a bold and vivid touch to the high-lying western mountain ranges (4). The U.S. Fish and Wildlife Service inventoried a total of 9,152 Rocky Mountain bighorn and 3,732 desert bighorn in the continental United States for 1943.

The bighorn is a large wild sheep, much larger than our domestic varieties. Mature males weigh from 200 to 300 pounds, and fully grown females weigh from 125 to 175 pounds (*13 g.r.*, *82 g.r.*). A conspicuous part of the males are the horns, which are massive, wrinkled, and sweep in a graceful curve to the back and side of the head. The females also have horns, but these are smaller and only slightly curved.

The anatomy of the bighorn is well adapted to rugged country. Its body is muscular, and the feet well protected, with cloven hoofs. So well are the bighorns adapted to the mountains that they travel over the most broken country with apparent ease.

Breeding Characteristics (1). Bighorn sheep breed at 2½ years of age with the females having young when about 3 years old (5). The rut begins in late fall and may last through November and December (5). In the Mount McKinley National Park the rut is well under way by Nov. 15 (*82 g.r.*). The gestation period of Wyoming bighorns is 180 days (3), and

[1] As pointed out by Anthony (*13 g.r.*) the genus *Ovis* contains a large number of species and subspecies. The present discussion refers more specifically to the following forms: Rocky Mountain bighorn (*O. canadensis canadensis* Shaw), desert or Nelson bighorn (*O. canadensis nelsoni* Merriam), and Dall or white sheep (*O. dalli dalli* Nelson).

lambs are born during the following May and June. Females have but one lamb and use isolated ledges on which to have the young. Both mother and young occupy these protected lambing grounds until the lamb is old enough to stay with the flock.

After the lambs are strong enough to travel with the flock, the sheep feed, travel, and rest together during both summer and winter, following a regular routine.

Pulling (6) found that mature ewes may not produce young, and presents the hypothesis that the long rutting period with many males breeding the females may cause sterility of the females. This investigator indicates that where the sex ratio is 1:1, the smaller number of males may be an advantage in respect to successful production of lambs.

Movements. The routine movements of bighorns are to feed during the early morning, rest during midday, feed again in the afternoon, and rest during the night. During the feeding period the sheep move along at a rather brisk pace, grabbing a bite here and a bite there as they travel. In Alaska Murie (*82 g.r.*) describes a migration of sheep from the winter to summer range during June and July and back again in August and September as snow covers the food supply in the fall. During each seasonal movement sheep sometimes travel from one ridge to another.

In dry country, the summer ranges center around watering places and caves where the sheep can obtain water, escape insects, and obtain relief from the intense summer heat. The rams travel considerably during the rutting season, going from one band of ewes to another.

White (7) describes a band of bighorns in Wyoming that start back to the summer range the last 2 weeks of May and begin the return journey about Sept. 1. With this herd the ewes and lambs come down to the lower levels first in the fall, the rams remaining behind until as late as December or January.

Food. Bighorn sheep are cosmopolitan in their feed preferences, eating the plants that grow in rocky hillsides and mountain meadows. Honess and Frost (5) list 37 plants that were seen to be eaten by these animals. Eleven on this list were recovered in stomachs, and ten additional plants were found that were observed during the feeding activities. Grasses are among the preferred foods taken in Wyoming. Of these bluestem (*Agropyron Smithii*), squirrel tail (*Sitanion hystrix*), rice grass (*Ericoma cuspidata*), prairie June grass (*Koeleria cristata*), and redtop (*Agrostis alba*) are listed as preferred. Each location where bighorns are found appears to have its own list of preferred and commonly used food plants. Thus, Cooney *et al.* (2) give silver sage (*Artemisia frigida*) as a preferred food in Montana.

Bighorn sheep are similar to domestic sheep in that they are able to get along with a minimum of water. In winter, moisture is taken largely in the form of snow, while in summer it is obtained from dew and from the

succulence of food. No doubt when water is available, bighorns use it freely; but when occasion demands, they can get along with a minimum amount in the free form.

Bighorn sheep, like domestic stock, need minerals and may not get sufficient quantities from their feed. Honess and Frost (5) show pictures of mineral licks and state that sodium chloride, lime, and phosphorous salts are the minerals conspicuous in the soil of these natural licks.

Comments. During the past decade considerable time and effort have been given to the study of the various bighorn sheep herds of North America. Census data of the U.S. Fish and Wildlife Service indicate that the herds gained slowly in numbers during the period 1937–1943. This gain may be due to better methods of estimating over the period, or it may be an actual increase in the numbers of sheep. Bighorn history shows that these animals fluctuate according to the severity of the weather, number of predators, and other factors. Probably little permanent gain will be made except by removing competitors such as deer and livestock from bighorn ranges and giving the bighorns better protection from human predation.

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CHAPTER XVIII

GRAY WOLF

Canis spp.

GEOGRAPHICAL DISTRIBUTION

Formerly the gray wolf was found throughout practically the entire continent of North America, a range that extended from the Arctic polar ice cap in the north to the tropical latitude of central Mexico in the south (2). This animal was very abundant and extremely destructive at one time in the wooded portions of the continent, and was a menace to the early settlers who pastured their livestock in openings in the adjacent forests. Its early stock-killing depredations are evidenced by the fact that the colonial records of Massachusetts show one of the first tax levies was to pay bounties to destroy wolves. Likewise at the time William Penn came to what is now Pennsylvania "packs of 500 wolves were noticed." In the early nineteenth century Thomas Meecham, during a lifetime of hunting in St. Lawrence County, New York, killed 214 wolves (*88 g.r.*).

At present the range of the wolf is much restricted, since it has been exterminated throughout much of its former territory. East of the Mississippi River wolves now are found only in the wilder northern parts of the Lake states—Michigan, Wisconsin, and Minnesota. West of the Mississippi, they occur in southern Missouri, western and north-central Arkansas, northeastern Louisiana, eastern Texas, Arizona, New Mexico, Oregon, and Washington. Likewise, they still are encountered over much of their original range in northern and central Mexico (2).

North of the United States the gray wolf has disappeared from Newfoundland and most of eastern Canada. In 1940 Clarke (2) estimated that there were 36,000 wolves on the Canadian Barrens, or about 6 wolves to 100 square miles. For this same year Young and Goldman give the number of wolves in Alaska as 7,000 and state that the trend of the wolf population in the Territory is on the increase. These same authorities quote Cahalane as estimating that the total number of wolves in the Mount McKinley National Park is 105 (2).

ANATOMY, LIFE HISTORY, AND ECOLOGY

The gray wolf resembles the German police dog in appearance and in some of its characteristics and habits. The ears are erect, and the muzzle

quite pointed, with the head, body, and tail covered with bushy coarse hair that may vary from gray through brown to black. White or cream-colored individuals are also known to exist (2). In weight, a mature wolf may weigh from 60 to 175 pounds, with 100 pounds as the weight of medium-large individuals. The gray wolves that formerly lived in New England and the Eastern states weighed from 50 to 60 pounds and possibly a little more (*13 g.r.*). The largest wolves of this continent are found in Alaska and the Mackenzie River district of Canada (2).

Young and Goldman state that the intelligence of the wolf is comparable to that of the domesticated dog. The tracks of this animal are also similar to that of the dog, differing only in size and the positions of the front toes. Likewise, the life span of 10 to 18 years for wolves is comparable to that of the larger breeds of dogs. In addition, in the north country of Canada both full-blooded wolves and hybrid crossbreeds of wolves and dogs are used by trappers and packers for draft purposes (2).

Wolves breed when between 2 and 3 years old and resemble dogs in their reproductive habits, but according to Young and Goldman (2) the mating is for life. The sexes are about equally divided. The gestation period is 60 to 63 days, or about 9 weeks. Breeding begins in early midwinter, and the young are born in a den from March to July depending on the latitude. The number in a litter varies from 5 to 14, the average being about 7 (2).

The young are blind when born and are nearly hairless. They open their eyes between the ninth to twelfth day (*88 g.r.*). The nest is a rocky cavern or a remodeled fox den. In the Mount McKinley National Park the nest was invariably underground (*82 g.r.*). Both parents assume responsibility for feeding the young, and in fact several individuals other than the parents may take part in the family activities (*82 g.r.*).

Movements. Wolves depend on fleetness of foot for their safety and welfare, evading a pursuer by the use of speed and distance, and secure much of their food by overtaking their prey. Murie (*82 g.r.*) speaks of the night hunting habits of wolves in Mount McKinley National Park, and both Olson (1) and Young and Goldman (2) described the hunting habits of these creatures. Generally these forays are circuits that may be from 40 to 100 miles in extent. Olson says that the pack may travel as far as 40 miles a day and the coverage of the circuit may take 2 to 3 weeks (1).

Actually the distance traveled by the wolves may be 400 to 500 miles. The route of travel appears to be well established and used repeatedly. These travel lanes include country that contains good game or ranch country and from which the wolves are able to take a sumptuous livelihood. High points are used for observation, resting, and defecation grounds. During winter the frozen surface of lakes and streams is included in the routes of travel.

Food. The food of the wolf is largely animal material, although some vegetable matter is taken. In Alaska and the barren grounds of Canada caribou are a favorite food of wolves, probably because of their abundance. Murie (*82 q.v.*) lists caribou, Dall's sheep, ground squirrels, marmot, moose, porcupines, ptarmigan, varying hare, beaver, grasses and sedges, garbage, and several miscellaneous items. Young and Goldman (2) give 22 items of food, including deer, domestic livestock, and practically all the birds and mammals present on the wolf range. Olson (1) sums up the food of the gray wolf in northern Minnesota as including deer, varying hares, grouse, wood mice, meadow voles, fish, marmots, snakes, insects, and some vegetation. As to quantity of food eaten, Olson says that a wolf can get along on three or four meals a month. This same investigator indicates that the 250 wolves on 2,500 square miles of northern Minnesota wilderness consume annually about 2,000 deer, or an average of 8 deer per year per wolf. He estimates that the total deer taken is not more than 10 per cent of the herd on a range that is in general not available to utilization by man.

Summary. Wolves have been eliminated from a greater part of North America. The conflict of these large carnivores with the interests of man is such that the wolf had to give way to the higher economic interests of human beings who depend upon the land for a living. No doubt this reduction of the number of wolves has been carried far beyond the actual need in remote wilderness areas and unused portions of the continent.

The wolf is one of the most colorful components of the wilderness fauna. While it is recognized that wolves cannot be tolerated where man cultivates the land and depends on returns from domestic animals for a living, yet a way should be found to maintain a population of all wilderness animals including wolves wherever possible. A detailed study of the ecology of the gray wolf should be made in the National Forests to determine the relation of this animal to varying hare populations and the indirect effect of wolf food habits upon the survival of forest tree species and forest composition. An investigation is also needed to determine the effect of wolves in keeping white-tailed deer populations within the bounds of their food supply.

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CHAPTER XIX

GRIZZLY BEAR

(*Ursus horribilis*)

GEOGRAPHICAL DISTRIBUTION

The grizzly bear is slowly vanishing from the western part of North America. Because of its destructive habits in relation to stock raising a relentless warfare has been waged to reduce its numbers.

The total number of these bears in the United States as given in the report for 1943 by the U.S. Fish and Wildlife Service is 1,265 animals, most of which are in Montana and Wyoming. Only three other states have grizzlies, these being Idaho, Colorado, and Washington. Murie (*82 g.r.*) gives a very detailed description of the grizzly bears in the Mount McKinley National Park but refrains from giving an estimate of their numbers.

LIFE HISTORY AND ECOLOGY

Female grizzly bears breed at the age of 3½ years, and the mating is monogamous for one season (2). Murie (*82 g.r.*) states that for the female at least, breeding takes place every 2 years or possibly with some females every 3 years. The young bears, numbering one, two, or sometimes three cubs, are born in midwinter, following a gestation period of 230 days (1, 2). At birth, the cubs are very small, weighing less than a pound, and stay with the mother for a period of 18 to 24 months. The young bears den up together during the second winter and may stay together through the third summer. They then separate and breed during their fourth summer. Grizzly bears may grow to weigh as much as 800 pounds, but the usual weight is not more than 500 or 600. Seton (*88 g.r.*) gives the weight of the largest wild grizzly as between 700 and 950 pounds.

Movements. Grizzly bears are large and well able to travel at rapid speeds for short distances at least. Movements are most likely to be at twilight but may also take place during midday or during total darkness. Seton (*88 g.r.*) states that although the ideal range is not swamp or open lands or high mountains, still grizzlies may be found in any of these situations. Movements are in response to the needs for getting food and to escape man and his dog and gun. In general this bear lives in a restricted area but may travel as far as 25 miles to get food. Murie (*82 g.r.*) gives the typical range of grizzlies in Mount McKinley National Park as being about

10 miles across but agrees with Seton (*88 g.r.*) that bears may travel as far as 25 miles to get suitable or desirable food.

Food. Grizzly bears are especially conspicuous during the period when they fish for salmon, in consequence of which a mistaken concept has arisen that these creatures are carnivorous rather than omnivorous. The fact is, however, that they eat mostly vegetable materials but will consume meat, including carrion, when it is readily available. They eat mice, snakes, ground squirrels, marmots, caribou, or domestic animals but in the wild state probably eat greater amounts of vegetable than animal foods. Early spring foods consist of roots; summer foods are chiefly green vegetation; and late summer and fall foods are mostly berries (*82 g.r.*). Grasses and horsetails contribute heavily to both the roots and vegetation that are eaten, and the fruits may be any of the berries native to the region, including blueberries, cranberries, and buffalo berry.

Comments. As reported for 1943, all but 58 of the grizzly bears counted were living in National Forests and National Parks. This number is larger than that given by Seton (*88 g.r.*), so it is presumed that the species is increasing slowly. The National Park administration has stopped the practice of pauperizing these noble creatures by feeding them garbage, which is a step in the right direction. Protection in the National Parks is assured, and appreciation of the need of protection has been expressed by the Forest Service. However, conflict with this philosophy will probably continue to be felt wherever the range of the grizzly and domestic animals overlaps.

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CHAPTER XX

MOOSE

Alces americana [1]

GEOGRAPHICAL DISTRIBUTION

The moose is one of the least handsome yet perhaps the most majestic of the North American mammals. This animal appears to lack symmetry but is well suited to the wild surroundings in which it lives. Its head is large, with a curved muzzle, and its sense of smell is keen. The ears and eyes are prominent, making the animal sensitive to both sound and movement. Its legs are long, strongly muscled, and well suited to travel through swampy muskegs and thick brush.

The range of the moose in North America extends from the limit of tree growth in the North to approximately the southern border of Canada. In the East, the range extends into Maine, New Hampshire, and Vermont. In the Great Lakes region, the range includes Isle Royale and northern Michigan as well as northern Minnesota. In the West, moose are found as far south as Wyoming. The *Big Game Report* of the U.S. Fish and Wildlife Service for 1943 gives the number of moose as 14,803 for the United States.

ANATOMY, LIFE HISTORY, AND ECOLOGY

In general the moose is about the size of a horse, the mature males being larger than the females. Although weights of 1,700 pounds for a bull moose are quite possible, the records of live animals usually show less than this weight. Newborn calves weigh 25 to 35 pounds and gain from 1 to 2 pounds a day for the first month and from 3 to 5 pounds during the second month, according to Kellum (4) for Isle Royale moose. Yearling males weigh 400 to 600 pounds, 2-year-olds 700 pounds, 3-year-olds 900 pounds, and mature bulls 1,000 pounds and up. Breckenridge (2) gives the weight of a male that was 5 or 6 years old as 1,065 pounds. Females weigh about 400 pounds as yearlings, 400 to 600 pounds as 2-year-olds, and 600 to 800 pounds at maturity.

The bell is a peculiarity of moose anatomy not found in any other of the deer family. It is a long, loose flap of skin hanging from the throat, which as far as can be determined has no useful purpose. This bell is found on

[1] Four subspecies of moose are listed for North America by Anthony (*13 g.r.*).

both males and females. In length, it varies with different individuals from 12 to 18 inches or even longer. The bell may be a sex character, but no valid reason for this suggestion is available.

Only male moose have antlers, a new set being grown and shed each year. The first year the antler is a mere button; the second year it has four points; the third year six points; and the fourth year eight points or more (4). The antlers are dropped during the winter sometime between December and March, depending on the physical vigor of the individual. The process of antler development resembles that of others of the deer family, the velvet being rubbed off and the antlers polished during the late summer before the mating season.

Breeding Characteristics. Female moose may mate at a minimum of $2\frac{1}{2}$ years of age. Although the males are probably physiologically ready to breed at that age, they may seldom get the opportunity because of the competition of older males. The rutting period begins in September and lasts for 1 or possibly 2 months (3). The bulls do a good deal of thrashing around looking for females and fighting other males during this period. It is thought that the male moose comes into breeding condition previous to the female and that he remains physiologically capable of mating for a week or two longer than females. Moose are polygamous, a male mating with as many females as he can find (*66 g.r.*).

The gestation period is 8 months or 242 to 246 days (4), and the young are born in May or early June. A female has one offspring as a result of the initial mating and may have one or possibly two or three young during subsequent breeding seasons (7). The cow seeks seclusion to give birth to the young but may have difficulty in getting rid of her calf of the previous season for this important event. The newborn calf is a solid light bay color when born. It remains in one location until it gains enough strength to follow the mother. At this time both the newborn calf and the offspring of the previous year may be part of the family group. Merrill (7) states that the young are able to swim at an early age and that calves born on islands are able to leave the island and swim to the mainland 3 or 4 days after birth.

The subject of barren females is one that frequently arises in connection with moose laws regarding the open season for shooting males only or both sexes. Murie (8) and Schierbeck (quoted by Murie) give excellent information on this subject. Murie, in describing moose observed on Isle Royale from July 16 to Sept. 11, notes that of 103 cows seen, 28 had calves with them and 75 were without calves. Also of 42 cows seen with bulls, 17 were followed by calves and 25 had no calves with them. Furthermore, of 83 cows observed in the spring between May 5 and June 20, 38 were followed by yearlings and 45 appeared to have no young with them. These data may be summarized as follows:

TABLE 69. SUMMARY OF THE NUMBER OF MOOSE COWS SEEN WITH AND WITHOUT CALVES AT ISLE ROYALE, MICHIGAN *

Season	Total cows seen	No. with calves	No. without calves	Per cent without calves
Midsummer.	103	28	75	73
Rutting period .	42	17	25	60
Spring.	83	38	45	54

* Murie (8) explains that it is quite probable that not all females seen in midsummer without calves are necessarily barren or nonbreeders, since cows are often seen without calves at this season

Figures from Nova Scotia give the number of females without calves as reported by hunters as 273 of 525 observed, or slightly in excess of 50 per cent.

Movements. Moose are most active at dawn and dusk, but some feed all night, while others feed and rest intermittently during the day (8). Under normal conditions a moose does not travel very far, being as Cahalane (3) indicates a "home body." Murie (8) cites one case of a bull that was seen not farther than 200 yards from the point where first noted and ½ mile distant at another time. Another bull stayed within a patch of willows not more than 200 yards square for a period of 4 days. Movements during the rut are more extensive, as the bulls will investigate the bellow of a cow even if it is several miles away. Also, during the winter period moose may go several miles in search of food if a sufficient supply is not available locally.

There is apparently a movement that may be designated as a "drift" from one point of a range to new locations (1). This is no doubt a gradual shifting of individuals to more suitable parts of the moose range. The moose on Isle Royale in Lake Superior apparently crossed the 13 miles of ice from Canada during the winter of 1912–1913. Merrill (7) quotes Robert Bell, Chief of the Canadian Geological Survey, as follows:

> The moose . . . migrates slowly from one large area to another through periods extending over many years. For example, in the Gaspé Peninsula the last interval between its leaving and returning to the same district was upward of half a century, and in the region between the Great Lakes and James Bay the period between this last withdrawal and reappearance has been still longer.

Seton (*88 g.r.*) gives numerous examples of drift movement of moose and describes territories now occupied by moose that were not occupied by this animal 40 to 50 years previously. During the fall of 1942 moose were seen along the Connecticut River Valley in Massachusetts, having migrated from east-central New Hampshire, the nearest known occupied moose range.

Population Density. A moose population may build up to compara-

tively high numbers if the borders of the range are of such nature as to prevent their dispersal. Seton (*88 g.r.*) speaks of 6 moose to the square mile on Grand Manitoulin Island in Lake Huron during the winter of 1670–1671. A high population built up on Isle Royale previous to 1930, which Murie (8) estimated may have been as high as 10 to 13 animals per square mile. With a barrier of water preventing dispersal, the moose on Isle Royale depleted their food supply and died of numerous causes brought on primarily by malnutrition.

The density of moose on the Superior National Forest in 1941 was one animal for each 5,742 acres, or about 9 square miles.

Food. A full-grown moose uses energy at a rapid rate and consumes large quantities of food to supply this energy. Kellum (4) found that mature animals required 40 to 60 pounds of food daily to supply their needs and that more was consumed in summer than in winter. Bark of trees and shrubs is eaten by choice, being a staple item in the spring, while herbaceous and aquatic plants are eaten freely during the summer period. A common sight in summer in the moose country is a moose nearly submerged along the border of a lake or bay with its head under water, grubbing water lilies from the bottom. Moose seem to thrive on water vegetation and seek the water to rid themselves of insects during the summer period.

Summer Food. According to Murie (8), the summer food of moose on Isle Royale consists principally of leaves, but twigs are eaten to a limited extent. He lists the following plants as summer foods: birch, poplar, hazel, bush honeysuckle, dogwood, alder, mountain ash, pine cherry, hard maple, sedges, large-leaved asters, and pond weeds. Willow, ground hemlock, mushrooms, thimbleberry, ferns, asters, jewelweeds, and grasses are all eaten when available. Murie says feeding on water vegetation is particularly pronounced in June.

Winter Foods. Winter food for moose consists largely of buds, stems, bark, and the leaves of coniferous plants. The deciduous plants eaten in summer are also eaten in winter (8). Northern white pine and white spruce are eaten sparingly. White cedar is eaten but not particularly relished. Balsam fir is one of the staple moose foods on Isle Royale and in eastern Canada, but spruce is the only common conifer eaten on Mount McKinley in Alaska. Alder leaves are eaten eagerly in summer, but the twigs are not relished by moose in winter. Willow is eaten extensively during winter in Minnesota.

Water and Salt. Moose live in a habitat that is unusually well watered. This creature is particularly fond of water, being either near it or in it much of the time during the summer season. No doubt huge quantities of water are consumed as part of the daily needs of the moose. Salt or at least the salty minerals are also much sought during the summer period, as indicated by the many salt licks on the summer ranges of moose. Murie

(7) describes salt licks as being low muddy areas full of standing water and much used by moose. Analysis of both the soil and water of such localities showed salts in aqueous extracts from ten hundredths to twenty-five hundredths of 1 per cent and consisting of calcium, ferric and magnesium sulphates as well as traces of calcium chloride or common salt.

MANAGEMENT

Census. Census methods for moose so far have consisted largely of ocular estimates based on sight records and signs of moose at salt licks, and the degree to which the vegetation is eaten. Murie (8) did not attempt an organized count of moose on Isle Royale even on a range where the population had reached exceedingly high numbers. Adams suggested a method in the U.S. Forest Service "Wildlife Handbook" (*2 g.r.*) consisting of a strip sample count by the use of an airplane, a method that has since been tried successfully for deer and other large game animals (see chapter on Deer). The U.S. Forest Service, Region 9, has used the strip count on samples of moose winter range on the Superior National Forest.

As already stated, a wilderness area ought to be large enough to give plenty of elbowroom for even a large free-ranging animal like the moose. Unlawful killing of moose by chronic violations of the game laws seems to be general where human beings live under pioneer conditions on the moose range. Manweiler (5) states that of a total of 34 dead moose found in northern Minnesota 14 died of gunshot wounds. Of those killed by shooting, partial use was made of only three of the carcasses. If conditions such as this are typical of the backwoods country found in wilderness areas, it appears that law enforcement should be a part of the administration of these areas.

The problem of overpopulation of moose will no doubt be an intermittent problem on Isle Royale in Lake Superior for some time to come. Since this area is a national park, the possibility of reducing the herd by allowing an open season is not possible under the present National Park policy. The presence of carnivorous animals like the gray wolf on the Isle may help to hold the moose herd in check, but an overpopulation of moose will always be a threat to good administration on this otherwise excellent moose range.

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CHAPTER XXI

PRONGHORN ANTELOPE

Antilocapra americana

GEOGRAPHICAL DISTRIBUTION

The antelope, or pronghorn, is at present perhaps the most typical of all the creatures of the plains and dry lands of the Far West. During its heyday, Seton (*88 g.r.*) estimated its numbers at 40 million, or equal in numbers to the bison. At its lowest ebb between 1915 and 1925 Seton quotes J. D. Figgess of the Colorado Museum of Natural History as placing the number for the entire country at 13,000. Since then a decided improvement in conditions has allowed the pronghorn to increase, so that in 1943 the U.S. Fish and Wildlife Service inventory was 246,090 antelope in the United States. There are probably not more than 5,000 antelope in Canada at the present time.

ANATOMY, LIFE HISTORY, AND ECOLOGY

Antelopes are smaller than eastern white-tailed deer. They have characteristic single-branched horns, the outer shells of which are shed each year. Both sexes have horns, but those of the male are larger and stronger than the female's. In color the sexes are alike, with dark brown hair above and lighter colored hair on the ventral side, as well as on the throat and rump patch. The tail is short. The females are slightly smaller than the males, weighing from 75 to 100 pounds when mature, while the males weigh from 100 to 125 pounds at maturity.

Breeding Characteristics. Antelope are mature at 5 years of age and may live to be 12 to 15 years old (9). The sexes are approximately equal in number (3). Breeding is polygamous, the males going from one receptive female to another during the period of the rut. The rutting period lasts about 2 months, through November and December. The gestation period is 240 to 250 days (3), and the kids, usually twins, are born in May or June.

Food. Pronghorns live where there is sparse vegetation and even in dry country where cacti are the dominating plants. They feed mostly on grasses, or when in settled country they may feed on domesticated plants. Skinner (9) gives gamma, buffalo, and bunch grasses as favorite foods, also alfalfa and oats. They likewise eat the leaves of some of the herbaceous

plants, including sage brush and many of the fleshy-leaved desert plants. Rouse (8) lists 15 species of plants, including weeds, grasses, and shrubs, used by antelope in Oklahoma. Salt and other minerals are relished, and water is a desirable part of the diet. Watering is done during the middle of the day, while the feeding period is in the morning and late afternoon. Einarsen (3) states that they are not particular about the quality of the water consumed, a dirty water hole being used as freely as clear spring water.

Movements. The pronghorn antelope is a creature of the dry plains where the vegetation is sparse. Here it depends upon eternal vigilance and fleetness of movement to escape its enemies. Since there is likewise a change in the vegetation from summer to winter, this necessitates movement of these animals in obtaining seasonal food. Skinner (9) mentions the migration of antelopes in former years, when these animals banded together in the fall and moved south to more attractive winter range. He describes the migration of antelopes in the Yellowstone National Park as extending for a distance of 30 miles and taking a period of 3 days to be accomplished. Beer (2) indicates that the seasonal movements of antelopes in Montana are not great but states that there is a general shifting of animals in the fall from the open plains to more protected parts of the range. A corresponding movement is noted from winter to summer range but is not clearly described in the literature.

Comments. Much of the range formerly occupied by antelopes in the plain region is now utilized for the grazing of domesticated animals. There are, however, large noncommercial grazing areas that should be reserved for the various species of native fauna such as the pronghorn antelope. Successful attempts at management of this animal are now being practiced. Unoccupied ranges in Arizona and Texas have been restocked with young antelopes (7) or with both young and mature animals that have been trapped and moved to the unoccupied range (5).

In Oregon public hunting is being used to remove surplus animals and to disperse concentrations of antelopes to desirable range. Einarsen (4) believes that controlled hunting with permits to take a predetermined number of animals is a desirable procedure. He also suggests that mass hunting be prohibited and that the hunting season be set early enough in the year (Oct. 10 to 15 in Oregon) so the horns will still be suitable for trophies.

Antelope in Wyoming have increased from an estimated low of 5,000 in 1904 to 55,200 in 1943. By use of the permit system 6,050 antelopes were killed in 1942 (1). The state of Wyoming is to be congratulated on its capable handling of this importance resource.

As better facts concerning these animals are obtained, better management will no doubt result. The increase of antelopes during the past 20

years indicates that the pronghorn antelope is not in immediate danger of extirpation.

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CHAPTER XXII

ROCKY MOUNTAIN GOAT

Oreamnos americanus (Blainville)

GEOGRAPHICAL DISTRIBUTION

The Rocky Mountain goat is the only one of the hoofed animals of North America that lives above the timber line. In this rugged habitat, where level surface is almost nonexistent and where clouds, gales, snow, and danger are always present, this wise member of the animal kingdom lives and thrives. Sure-footed, cautious, brave, and rugged, the goat is able to garner a livelihood from the meager vegetation and to use the uneven topography for protection from both the elements and its enemies.

Rocky Mountain goats are found in the United States in Washington, Oregon, Idaho, South Dakota, and Alaska, and in Canada in British Columbia. Seton (*88 g.r.*) gives the number of these animals in the United States for 1925 as 15,000. The estimate by the U.S. Fish and Wildlife Service for 1943 is 16,100, so these animals appear not to be increasing much if at all.

ANATOMY, LIFE HISTORY, AND ECOLOGY

Exceptionally large male goats may weigh more than 200 pounds. In general, however, the weight and size of these goats are about the same as that of domestic sheep. The prime fleece is pure white, which may show soiled spots here and there in addition to a few dark-colored hairs. The head is adorned with small black horns from 6 to 8 inches long and needle-sharp. The sexes are similar in markings, and both have horns. The head adornments are not impressive, but heads and skins are prized trophies because of the difficult conditions of hunting these animals. Seton (*88 g.r.*) believes that they are probably monogamous, and no good evidence is at hand to refute this implication. The females breed at 2½ years of age and bear young when approximately 3 years old. The gestation period is 6 months (2, *88 g.r*). Two young may be born, but there is little evidence as to whether one or two kids is the rule. In South Dakota Harmon (1) found that the young are born in April. This same authority claims that an increase of 20 to 25 per cent for a herd, as a whole, is possible each year.

Food. The Rocky Mountain goat eats normally at sunrise and sunset,

resting during the time between. In summer the fare is grass, brush, moss, and lichens that grow between the rocky outcrops of the range. In South Dakota Harmon (1) gives the winter and spring food of Rocky Mountain goats as moss and lichens, 60 per cent; bearberry, 20 per cent; pine twigs and needles (*Pinus ponderosa*), 10 per cent; and miscellaneous (including ferns, grasses, currants, juniper, serviceberry, rose, willow, and erigeron), 10 per cent. Swift (2) includes aspen and birch in the spring and summer diet.

Range and Increase. The range of the Rocky Mountain goats is so precipitous that it is difficult to estimate how much area is needed to support one animal. Seton (*88 g.r.*) gives a variation of 3 to 15 goats per square mile. In the vicinity of Harney Peak in South Dakota Harmon (1) gives the number of animals as 200 in 1942, which had increased from a herd of 6 goats (four females and two males) brought from Alberta, Canada, in 1924. Swift (2) gives the range of 25 of these goats as covering an area of 20 square miles, but Harmon does not state how much territory is occupied by the 200 animals that he estimated comprise the Harney Peak herd.

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CHAPTER XXIII

WOODLAND CARIBOU

Rangifer caribou [1]

GEOGRAPHICAL DISTRIBUTION

The caribou is the North American reindeer; it ranges much of the territory in the northern half of the continent wherever civilization has not dominated or changed the range. The woodland caribou formerly occupied range in Maine, New Hampshire, and Vermont, as well as in the northern part of Minnesota, where a small herd is still found. The mountain form of caribou was found along the Rocky Mountain zone and is still found there in Canada. The barren-ground caribou roams the vast stretches of northern Canada.

ANATOMY, LIFE HISTORY, AND ECOLOGY

The caribou is the only North American deer in which both sexes bear antlers. These antlers are slightly palmated or flattened and branching. Both sexes lose the antlers each season during the colder parts of the year. According to Seton (*88 g.r.*), the stronger males lose their antlers first, thus giving the weaker individuals the advantage during a time when there is a shortage of food. Under these circumstances the females can force the males away from choice bits of food after the males have dug away the snow.

Woodland caribou are larger than white-tailed deer but smaller than moose. Mature males weigh from 200 to 300 pounds and are about 6 feet long. Females are slightly smaller.

The color of the caribou is a light brown, being darker along the back and lighter at both forward and rear extremities. The hair is inclined to be rough and ragged-appearing; it acts as insulation against cold and as a buoyant material when the animal crosses streams as it migrates throughout the range. The feet of the caribou are broad and awkward-looking but are well adapted to the animal's environment and mode of life. Being broad and capable of spreading, the feet give greater surface contact

[1] Anthony (13 *g.r.*) lists three main groups of caribou: woodland caribou with two subspecies of *Rangifer caribou* and one of *R. terraenovae* Bangs; the mountain caribou, a larger and heavier animal than the woodland species; and the barren-ground caribou, characterized by a smaller body size than either of the above forms.

when the animal travels in deep snow and over boggy muskegs. They also serve well while the animal is swimming and have sharp hard ridges that prevent slipping when the animal travels on icy surfaces.

Mating activities take place during the fall months. Murie (*82 g.r.*) gives the period of rut for the caribou in the Mount McKinley National Park as September and October. The gestation period is 7 months, with calving taking place during the following May and June. One calf is the rule, but Seton (*88 g.r.*) claims that twins are possible. The young stays with the mother from the time of birth; both mother and young join the herd within a day or two after the calf is born. According to Murie (3, *82 g.r.*), calves are precocious, developing strength remarkably soon after birth. The young feed on both milk and vegetation until about the mating time, but this is probably about the maximum length that the young receive nourishment from the mother (3).

Movements. There is one characteristic of caribou that is prominent above all others: its desire and ability to move about. The natural capacity of its range to produce cover is small, and the quality of the food is low. Thus, these deficiencies in relation to the caribou require the animal to move about freely and quickly, and this it does. Movements are from 10 to 100 miles a day. In addition many short moves may result from locally poor pasture, storms, disturbances by man, and predatory animals. Other movements appear to be associated with hereditary migratory habits, response to seasons, abundance of calving and breeding grounds, and possibly the changes of daylight and darkness. Murie (3) is convinced that in the case of elk the cause of migrations is the search for winter food, and this is also the case with caribou in relation to availability or palatability of fall and winter foods.

Foods. Murie (3) lists 32 kinds of plants eaten by caribou during a year. Grasses and sedges, lichens, mosses, willows, and birches account for 80 per cent of the entire diet. Of these foods grasses, sedges, and lichens comprise 54 per cent of the total diet. For the caribou as with many other animals the winter period is the lean season. Lichens are probably the mainstay during that season, although willow and birch stems, grasses, sedges, and mosses are utilized when available (3, *82 g.r.*).

During spring and summer lichens give way to the more succulent foods that are everywhere available in the northern range. Murie (*82 g.r.*) found that grasses and sedges form the bulk of the summer food. Early in the season, however, willow and dwarf birch in the form of catkins, twigs, and leaves supply food to these animals. No doubt large numbers of incidental plant items contribute to the food list of the caribou. Even the shed antlers and material from muskrat houses are eaten during the period of food scarcity.

Historical. In the entire United States woodland caribou now number

only 25 animals—10 in Washington and 15 in Minnesota (1, *57 g.r.*). Although the range of the caribou in this country was never extensive, it has shrunk to a small area in the Red Lake district of Minnesota and one in Washington.

Until 1935 the Minnesota herd was being depleted rapidly by poachers and natural causes, but at that time a combined effort was made by the Minnesota Conservation Department and the U.S. Bureau of Agricultural Economics to save this herd from extinction. A fence was placed around 1,500 acres of the most suitable part of the range, and special protection was given to the remaining herd, which then numbered only six animals.[1]

Additional details concerning the efforts made to prevent the woodland caribou from being exterminated in Minnesota are described by Cox. In 1937 the Red Lake herd comprised only three cows, a herd of not very prepotent components. Ten caribou, including a mature male, were captured in Canada and were added to the herd in 1938. Dorer believes that this male has mated successfully with the three native cows, since a female caribou and calf were seen as late as 1943.

It is hoped that this herd will be given such complete protection and encouragement that the United States will not be "debited" with adding another splendid species of wildlife to the list of exterminated native animals.

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CHAPTER XXIV

DISEASES AND PARASITES OF WILD ANIMALS

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INTRODUCTION

A simple definition of disease is "any abnormal condition of the tissues of the body," while a popular definition for a parasite is "any living organism that lives in or on and at the expense of another living organism." The usual way in which disease is discussed in literature is to consider each condition as due to a definite cause and if it is a germ or parasite disease to attribute the cause to a specific germ or parasite. Unfortunately, to the confusion of the diagnostician, observed abnormalities may be and often are due to several primary and secondary causes which may or may not be interrelated or interdependent in a definite way. Thus, inherited abnormalities, faulty nutrition, exposure to adverse conditions, poisons, improper elimination, injuries, and other situations all may complicate the picture of disease.

Just one illustration will be given from the author's research experience. It now seems doubtful if lungworms as such mean much to a wild, otherwise healthy, deer in a suitable normal environment; but given an abnormally high population of deer, the adult deer generally infested, environmental and intermediate host conditions such that fawns have early opportunities to become heavily infested, an unbalanced condition of the sexes so that fawns are born abnormally late and thus fail to attain the proper growth by the onset of winter, a shortage of food and resultant malnutrition, weather conditions such as an exceptionally severe or an exceptionally late winter storm—then fatal lungworm pneumonia is apt to kill a high percentage of the fawns before they get through the first winter of their lives. The preceding discussion seems to be rather complicated, but the author feels that he has an abundance of field data that warrants drawing such conclusions.

A mistake commonly made by the laity and even by pathologists and parasitologists when dealing with wild animals found sick or dead is to assume that the mere finding of pathogenic organisms in these animals is diagnostic of the specific disease that such organisms might cause. One of the most baffling problems of control is that an apparently healthy animal may harbor disease-producing organisms that may be fatal to another individual.

If the reader will keep these conditions in mind, he will feel less frustrated when he himself fails to diagnose a disease situation properly and more tolerant toward the professional pathologist who, skilled though he may be in laboratory procedures, where all steps can be controlled and measured, fails to interpret fully situations concerning diseases of animals in the wild.

Since there are no differences involved in the principles that govern disease of wild animals, domesticated animals, and even man, the usual procedure will be followed in describing a few of the diseases that may come to the attention of the wildlife manager. This will involve brief discussion of causes, transmission, prevention, and control. A working classification partly natural and partly artificial will be used.

CLASSIFICATION OF DISEASES

It is customary to classify diseases according to cause or causal organism, to the animal affected, and to the system or organ or part of the animal affected. In this brief chapter some attempt will be made to group after this manner the examples used. However, to make the information given more practical, another type of grouping will also be used. This will be an attempt to show what diseases or conditions of disease one might expect to find as regards a purely artificial grouping such as (1) upland game birds in captivity, (2) waterfowl in captivity, (3) big-game animals in relation to livestock, (4) animal diseases transmissible to man. Diseases of fur-bearing animals in captivity are such a large subject that no discussion of it will be attempted here.

DISEASES OF UPLAND GAME BIRDS IN CAPTIVITY

The diseases described have been selected from those which have caused the most trouble at game farms.

Bacterial and Virus Diseases

Because of the controversial findings and the inability in some cases of pathologists to demonstrate the nature of the causal organism, the author has followed the plan of Shillinger and Morley (9) in grouping bacterial and virus diseases together.

Tuberculosis. During the author's experience with game farms that began before artificial incubation and brooding of upland game birds had become general, he has observed this disease in practically all species of pheasants, grouse, and quail that were being reared. One finds it especially in show birds and others that are retained until they are relatively old, as contrasted to such species as the ring-necked pheasant, bobwhite quail, and California valley quail, which are commonly reared for stocking and distributed before they are a year old.

Cause. Bacteria, *Mycobacterium avium.*

Transmission. Through food contaminated with the droppings of birds in a late or generalized stage of the disease.

Symptoms. Not until the disease has reached an advanced stage does one recognize it by symptoms of listlessness, drooping feathers, pallor of comb and wattles, and stiffness of leg joints. Although "going light," *i.e.*, pronounced loss of weight, is a symptom that game-farm employees swear by, the author has seen cases where death was caused by this disease when the bird was in excellent flesh. In birds that have comb or wattles the disease can be diagnosed by means of the tuberculin test. In those like the pheasant, the inoculation with tuberculin can be made at the side of the vent, but this method is not entirely satisfactory.

Lesions. At autopsy, a tuberculous bird will show nodules or tubercles usually of a yellowish color in the spleen, liver, and, in advanced cases, the intestines. In the miliary type the liver lesions may be of pinhead size and so numerous as to give the liver a pebbly, grayish appearance. There is great variety in the number and size of lesions. The lungs are as a rule not involved. Sometimes in late generalized cases involving the intestines, yellow gelatinous masses will be found in the visceral air sacs.

Prevention. Testing, culling, and maintaining sanitary premises free from tuberculous birds of any species are necessary to prevent avian tuberculosis.

Control. There is no practical treatment for infected birds, although many birds recover spontaneously from mild infections.

Ulcerative Enteritis. This disease of the digestive tract is probably bacterial in nature; and although it may exist as a low-grade chronic infection, it is especially dangerous when it becomes acute and sweeps like wildfire through pens of confined birds such as the bobwhite quail, California valley quail, and ruffed grouse, killing great numbers of birds in as short a time as 3 or 4 days.

Cause. Bacteria or virus. Causal organism in doubt.

Symptoms. In acute cases the most pronounced symptom is the violent diarrhea characterized by the white deposits on the floor of the pens. Chronic cases are not easily differentiated from other conditions of disease that cause unthriftiness and loss of weight.

Lesions. When death occurs early in the infection, the only lesions at autopsy discernible to the naked eye may be inflammation of the digestive tract, showing small hemorrhages. In a later stage the small intestine will be a mass of whitish-colored ulcers, some of which may be perforated. The intestine is extremely friable and tears readily.

Prevention. Since birds in the wild are not known to have the acute form of this disease, and since it is commonly associated with unfavorable circumstances for penned birds, such as overcrowding, rainy weather, and

unsanitary pens, it is evident that sanitation and proper care are the best preventatives. Recently captured wild birds or new lots of domestically reared birds should not be placed in pens with other birds that may apparently be well but are carriers of this disease.

Control. There is no known control or satisfactory treatment for diseased birds.

Fowl Pox (Avian Diphtheria). Common in the domestic chicken and sometimes found in upland game birds in the South, this disease is characterized by the presence of raised ulcers in the mouth and by wartlike nodules or sores on the head.

Cause. A virus that produces cell inclusions known as Bollinger bodies in the epithelial cells.

Transmission. Direct through scratches or abrasions in the skin; also known to be transmitted by the mosquito *Culex pipiens* and by chicken fleas.

Symptoms. In chronic cases symptoms are inconsequential and ordinarily escape detection. In acute cases in young birds the nostrils are involved and a viscid discharge causes the bird to breathe through its mouth. A watery discharge from the eyes may gum up the lids and interfere with vision. Later, if the bird lives long enough, the characteristic lesions noted above will develop.

Lesions. As noted in the previous paragraphs, the lesions are associated with the head and mouth.

Prevention. Since this is primarily a disease of poultry, keeping game birds away from poultry is the most logical procedure.

Control. Vaccination has been perfected for poultry and could perhaps be applied to game birds if conditions warranted it. Individual treatment of valuable birds by swabbing away the accumulations of secretions about the head and treating with an antiseptic will assist a bird to recover.

Protozoon Diseases

The author has made the statement that in his opinion, protozoon pathology of game birds is of equal importance with that caused by bacteria. In venturing such an assertion he had in mind, primarily, coccidiosis, blackhead, and *Leucoctoyzoon* disease, commonly called a malaria-like disease. Unlike the bacterial and virus diseases previously discussed, none of these protozoon diseases seem to be especially restricted to birds under game-farm conditions but are readily found in the wild as well.

Coccidiosis. The parasites responsible for coccidiosis in birds belong to the genus *Eimeria.* They all have a similar complicated life cycle and attack the digestive tract only.

Cause. These various species of *Eimeria* are usually host-specific, and

one would not expect a pheasant to become infected with species common to poultry.

Transmission By ingesting the droppings of infested birds, usually in contaminated food. Food may be mechanically contaminated by insects, small mammals, and birds and even by the shoes of man. The oöcyst stage is the infective stage. Technically, sporulation of the oöcyst must take place before the sporozoites formed through this process of sporulation are able to produce infection.

Symptoms. Since apparently healthy birds may harbor coccidia and give off oöcysts, and since chronic cases vary from extremely mild to those causing debilitation, no attempt will be made to list symptoms of this disease when it is in a mild or chronic state. When the disease is acute, the extensive destruction of the walls of the intestine may produce bloody diarrhea.

Prevention. Sanitation in disposing of litter, exposing pens to sunlight, and digging up and turning over the soil in the pens are advisable. Raising birds on wire is an effective preventative. It has been generally observed, however, that birds which have suffered light infections while young become immunized or resistant as they grow to maturity. Some investigators question the advisability of raising quail coccidiosis-free on wire and then liberating them as adults, since such birds might still be highly susceptible to coccidiosis.

Control. It is probable that the vaunted efficacy of various medicants for the treatment of coccidiosis is based upon a fallacy. This occurs when oöcysts appear in large numbers in the droppings and treatment is then administered, oöcyst production falls off, and the bird recovers. The explanation is that at this stage the disease has reached its climax and the host gets the upper hand and will recover regardless of the administration of medicants.

Blackhead (Enterohepatitis). In spite of the fact that this name is a misnomer, it persists and appears to be soundly established in the literature. It is a serious protozoon disease of young birds, particularly turkeys, quail, ruffed grouse, and Hungarian partridges; it is not unusual for 30 per cent of the young birds to succumb to this infection when once it gets started in a flock.

Cause. Histomonas meleagridis, a protozoon that develops in the caeca, then the intestinal wall, and finally is carried to the liver, where it produces lesions throughout this organ. On the outer surface of the liver they are circular in outline.

Transmission. Through food contaminated by droppings. There is evidence that caecal worms contribute to the spread of the disease, as the infective organism may be carried by the eggs of the worms and remain in the soil from one season to the next.

Symptoms. It is difficult to set up a list of distinctive symptoms. If at the age of about 6 weeks a flock of turkeys show loss of weight, with a few deaths apparently not preceded by distinct symptoms, blackhead may be suspected. Diseased birds will be sluggish in their actions. If autopsies of several birds show lesions as described below, it will be a conclusive evidence of blackhead.

Lesions. In turkeys and ruffed grouse the liver will be covered with flat, slightly sunken, circular areas of necrotic tissues. The caeca may be inflamed, enlarged irregularly, and contain cores of cheesy material. In quail the liver lesions are more diffuse.

Prevention. There is no prevention other than keeping the premises free from infected birds and controlling caecal worms. The organism is most virulent, and if young birds are reared with diseased old birds, they are almost sure to acquire the infection.

Control. Blackhead is by no means 100 per cent fatal, and many birds recover from it. It is also probable that claims made for medicinal cures merely represent normal recoveries. The author has seen whole flocks of birds treated individually by the administration of colloidal iodine directly into the gizzard through a long hard rubber tube inserted through the gullet, and he must admit that the results appeared to be good. He has also seen this method fail to produce appreciable results.

Leucocytozoon Infections

Although many species of birds, both domestic and wild, are known to harbor protozoon parasites of the genus *Leucocytozoon* in their blood, only a few species are noted for the pronounced pathological effects that they produce in the host. Turkeys, both domestic and wild, are parasitized by *L. smithi*, the ruffed grouse by *L. bonassae*, and ducks of many species by *L. anatis* (known to be a synonym of *L. ziemani*).

Leucocytozoon Disease of Turkeys. *Cause. Leucocytozoon smithi.*

Transmission. Biologically by the bites of the black fly *Simulium townsendi* and possibly other species of black flies.

Symptoms. Pronounced acute sickness, developing in young birds suddenly. The birds refuse food, are feverish and thirsty, get down and are unable to walk. They may crawl about some until death ensues in a few days.

Lesions. The presence in the blood stream of numerous spindle-shaped microorganisms which have developed inside and have destroyed certain blood cells. An enlarged blackened spleen is usually characteristic.

Prevention. In countries where black flies exist, young birds should not be reared near adult birds known to be carriers of this pathogen. Microscopic examinations of the blood will disclose the presence of the

parasites. Young birds can be reared in screened enclosures; but to prevent the entrance of black flies, the screen must have a finer mesh than ordinary window screen.

Control. As far as the author is aware, no effective medicinal procedures have been worked out.

Leucocytozoon infections in the ruffed grouse and the sharptail grouse are extensive in wild birds in Michigan. There is field evidence that the pathogenicity in the wild is not so severe as it is for turkeys in captivity. The author has had no experience with large-scale infections of grouse in captivity. Field evidence indicates that transmission is by one or more species of black flies.

Leucocytozoon Infections of Ducks. *Cause.* *Leucocytozoon anatis wickware* (*L. anatis* is now known to be a synonym for *L. simondi*).

Transmission. Biologically by the bite of the black fly *Simulium venustum* and possibly other species of black flies.

Symptoms. Largely a disease of ducklings; especially susceptible are the downy young before the contour feathers develop. Recovered adults may be carriers of the parasite. Both in the wild and in captivity, losses may be heavy, running from 35 to 85 per cent, depending upon the intensity of the initial infections. The most characteristic feature of this disease is the suddenness with which it strikes. After being bitten by infected flies, the young duckling will be apparently normal until about the tenth day. Then within 4 hours it suddenly becomes listless, refuses food, squats or lies down persistently, and will sometimes crawl to water. After taking a drink of cold water, the duckling may tumble about in a wild spasm which may end in death. More often, however, death comes quietly, the bird gradually becoming weaker. In 2 to 5 days after the onset of visible symptoms the duckling either dies or recovers. Older ducklings or adults may live for weeks and finally succumb. Usually older birds recover.

Lesions. Characteristic spindle-shaped organisms seen microscopically in the blood and a greatly enlarged and blackened spleen.

Prevention. The same as outlined for *Leucocytozoon* infections in turkeys. There appears to be no practical way of controlling this disease in the wild. It seems probable that the high death rate of young birds and the theoretical elimination of weakling (recovered) carriers in the migratory flight will tend to reduce the chances for new infections each year. It is not good practice to rear domestic ducks or captive wild ducks near breeding grounds of wild ducks for fear of exposing the young to this disease.

Control. Clues to control have already been given in the preceding paragraph, but a complete discussion of management practices dealing with the various biological complications involved would be too lengthy for treatment here. The possibility that biting insects other than black

flies may still be found to transmit *Leucocytozoon* infections should not be overlooked.

DISEASES OF WATERFOWL IN CAPTIVITY

The success that operators of duck farms have had in rearing thousands of the birds in a relatively small space demonstrates that ducks can be reared in an artificial environment. However, most of the ills that beset waterfowl in captivity are those associated with abnormal conditions of penning or handling and feeding. In wing-clipped birds fungus infections of the lungs and air sacs are common. This is possibly due to the inability of the birds to exercise their wings properly, which interferes with normal breathing. The most common pathogenic fungus appears to be *Aspergillus fumigatus*, which causes the disease known as aspergillosis.

Aspergillosis. *Cause.* A fungus, *Aspergillus fumigatus.*

Transmission. Through inhaling the spores of the fungus. Since these spores are universally distributed and since infections in birds are relatively few in number, it would appear that some predisposing cause such as unthriftiness and lack of complete ventilation of the lungs may be primarily responsible for the onset of the disease.

Symptoms. This disease develops slowly, and symptoms of difficult breathing and being easily exhausted develop gradually.

Lesions. Only at autopsy does one find the typical mycelium of the fungus growing in the lungs and air sacs. If the growth is considerable, there will be a gray appearance of these organs. At autopsy, the mycelium of the fungus can be seen with the aid of a compound microscope.

Prevention. Housing in winter, if provided, should be free from dust, and the bird should not have access to moldy straw or hay or moldy food of any kind. Wing clipping, as has been mentioned before, is probably conducive to the development of this type of infection.

Control. There is no practical control for alleviating the symptoms of this disease, although vigorous birds are probably able to throw off the infection and recover.

Botulism. This bacterial disease is not often found in captive birds, but ducks reared under conditions of semidomestication on marshes in a botulism-contaminated area are readily susceptible.

Cause. Clostridium botulinium, type C.

Transmission. Through ingesting the toxin produced by the action of the bacteria in a suitable medium.

Symptoms. Sudden onset with progressive loss of nervous control over the muscles. The bird first loses the power of flight, then of diving, of swimming, and finally of supporting its head on its neck. In this stage it can merely sit or crawl about weakly and finally is completely prostrated. This disease attacks birds of all species and all age classes.

Prevention. In western America, where large areas of brackish shallow water containing decaying vegetation are available to the birds, prevention is a practical impossibility when once the infection has become established in any season. Where water levels can be controlled and gently sloping shallow margins be prevented from forming in ponds, botulism is not so likely to be a problem.

Control. When the numbers of affected birds in an area are small, limited individual rescue of birds not too hopelessly weakened is possible provided that man power is available. Birds thus rescued will recover readily when given clean water and good food. Some investigators believe, however, that birds thus recovered can still carry the germs of botulism to those in the wild and thus perpetuate the infection. But this would not be different from what happens every day in nature. Certainly many mildly sick birds do recover. On refuges and on private hunting grounds where labor for management is plentiful, providing small islands stocked with food and pure water, where birds can crawl out of the contaminated ponds, is useful. Such island refuges, especially if they contain some brush for shelter, give needed protection from predatory birds, and the island nature of the refuge would ordinarily protect them from attacks by coyotes, foxes, and other predatory mammals.

Poisoning of waterfowl due to the mineral selenium found in Western soils of shale origin has sometimes been mistaken for botulism. Lead poisoning may also be found at the same time and place as botulism. The author will not attempt to set up criteria by which all cases due to these various causes can be segregated. Lead poisoning, however, is sufficiently well known so that it can be diagnosed rather well by one skilled in making differential diagnoses involving laboratory tests. For the purposes of this chapter, however, lead poisoning will be discussed largely from its field aspects.

Lead Poisoning. *Cause.* Ingesting lead shot.

Transmission. Not transmitted from one poisoned bird to another.

Symptoms and Lesions. As the lead ingested is ground up in the gizzard, it is absorbed, causing extensive losses in ducks and geese. Due to the lack of specific symptoms readily discerned by the average observer, the weakness and progressive paralysis resulting first in loss of flight may be erroneously attributed to botulism. A gorged proventriculus and the presence of lead shot in the gizzard, however, are rather conclusive diagnostic findings. Chemical tests that demonstrate the presence of lead in the viscera give more positive evidence.

A factor that is apt to mislead one as to the extent and seriousness of lead poisoning is that lead poisoning, perhaps more than any other disease of waterfowl, produces stragglers. That is, in the migratory flight as birds stop to rest and feed, those which have been weakened by lead poisoning

remain whereas others go on with the flight. If the average number of resting birds on any particular marsh is 1,000 and if 2 per cent of any flock have lead poisoning, this number would be apparently of little consequence. But suppose that 10 flocks of 1,000 birds each use this feeding ground consecutively over a period of a couple of weeks and each flock leaves 2 per cent as stragglers. Then a cumulative 200 sick or dead birds in an area where 1,000 normally stop to rest and feed at any one time give an alarming picture of loss and cause the observer to think that 20 per cent of the ducks as a whole are diseased.

Prevention and Control. Obviously as long as waterfowl have access to lead shot as the result of the expended charges of shot falling into shallow water where the birds feed, there is little that can be done about it. Why the birds continue to pick up shot in spite of the presence of food and grit is not understood. Some years ago, experimental work looking toward the manufacture of shot that would soon disintegrate and not be available to the birds was undertaken. This remedy, however, has never been put into practice.

The tonnage of lead contained in duck marshes that have been shot over for decades is enormous, and the author knows of no practical way to keep waterfowl from ingesting these lead pellets.

DISEASES OF BIG-GAME MAMMALS IN RELATION TO LIVESTOCK DISEASES

Since deer, elk, antelope, buffalo, moose, reindeer, caribou, musk ox, mountain sheep, and goats are rather closely related zoologically to either domesticated sheep or cattle, it is not surprising that there should be disease interrelationships among them where the animals have joint occupancy of land. Many parasites, both external and internal, of various species are closely related or identical. Fortunately, however, there have been few examples of major outbreaks of disease of wild animals among livestock or vice versa. The disastrous spread of foot-and-mouth disease to deer on the Stanislaus National Forest in California in 1925–1927 should serve as a warning to wildlife managers to be continually on the alert in recognizing disease in wild ruminants and reporting it promptly to the proper officials. This particular outbreak required the slaughter of over 22,000 head of deer, along with many thousands of head of livestock, to stamp out the outbreak.

To discuss only a few examples of such diseases and parasites would require space beyond the limits of this chapter, and in the matter of prevention and control one can readily see the impracticality of such controls as involve vaccination, medication, or individual handling of wild ruminants.

The livestock owner and manager prevents and controls disease through controlling animal populations, through using the services of veterinarians

and other scientifically trained personnel, and most of all through keeping his livestock moving by culling and marketing and not allowing animals to become diseased and die as a result thereof. We apparently have a long way to go to attain this point of view in wildlife management, which would of necessity involve drastic changes in game laws and their application. Fortunately, in wild areas least changed by man and his livestock, the natural biological law of the survival of the fittest is operating 365 days a year and tends to keep disease and parasitism, as well as the hosts that they attack, under control.

Lest the student and general reader be too much disappointed in this chapter, an example will be given of a disease representing each class of causal organism, with an attempt to set up the discussion in a form comparable to that used in preceding pages.

Foot-and-mouth Disease. *Cause.* Virus.

Transmission. Direct contamination of the premises and food of susceptible animals through such secretions as milk, saliva, urine, exudate from vesicles, and possibly other secretions and excretions of an affected animal. The meat and other parts of the carcasses of animals that die or are slaughtered in the febrile stage of the disease are infectious. The virus can be readily spread mechanically by man and other animals, hence the reason for the rigid quarantine laws enforced in the United States.

Symptoms. Diagnosis is the job of an expert, but vesicles or blisters and lesions on the mucous membranes of the tongue, lips, and cheeks and between the hoofs of cloven-hoofed animals are significant.

Prevention and Control. Quarantine and slaughter of diseased animals and those which have been exposed.

Brucellosis, Bang's Disease, Infectious Abortion. *Cause.* Bacteria, *Brucella abortus.*

Transmission. By direct contamination of food and drink or by a susceptible animal licking a contaminated object.

Symptoms and Lesions. Not definitely known for big-game mammals, but by inference in relation to those of cattle, abortion or loss of fetus before term and reduction in milk flow. Diagnosis is made by laboratory (agglutination) tests by skilled technicians.

Prevention and Control. There is probably nothing we can do about it as regards animals in the wild, but animals used for restocking should be tested before being liberated.

Anaplasmosis. *Cause.* Protozoon, *Anaplasma marginale,* parasite in the red blood cells.

Transmission. Naturally through bites of infected ticks. Since it may be spread in cattle by unclean surgical procedures, there is a possibility that fighting by bucks resulting in antler punctures, particularly broken antlers, could transmit this disease.

Symptoms and Lesions. In the present state of our knowledge, about all we know about this disease in deer is that experimentally it is transmissible to the Columbian black-tailed deer. By inference, the symptomology should be similar to that in cattle. This is a high fever, great destruction of red blood cells, depression, loss of appetite, and yellowing of the whites of the eyes and visible membranes. Dribbling urination and constipation are common symptoms. Diagnosis is made by an expert in blood protozoa or hematologist. There are, however, other diseases with which it can be confused, hence the desirability of making other laboratory tests.

Prevention and Control. In cattle, since animals that have recovered from this disease are carriers, the problem of control is an exceedingly difficult one. No practical way is known for controlling it in deer.

Liver Fluke Disease. *Cause.* The large liver fluke, *Fascioloides magna.*

Transmission. Through acquiring an encysted larval stage (cercaria) in drinking water or on food taken about the water.

Symptoms and Lesions. The flukes, which at maturity are thick, flat, leaf-shaped worms up to 2½ inches long and ¾ inch wide, develop in the bile ducts of the liver and cause pockets to erode. This infestation is very common in deer, and normally they recover. In livestock, particularly calves, damage to the liver is so extensive that the livers must be condemned by slaughterhouses, and a considerable economic loss results.

Prevention and Control. Where the snails that serve as intermediate hosts of these parasites are widespread in areas where deer feed and drink, little can be done about preventing this infestation. Control of the snails through treatment of the water with copper sulphate as is sometimes done for sheep and cattle is not usually practical for deer.

DISEASES OF WILD ANIMALS TRANSMISSIBLE TO MAN

It is not possible to differentiate animal diseases transmissible to man from those carried by domestic animals only and those carried by wild animals. It should be made clear at the outset that the numbers of ectoparasites and endoparasites and of diseases of animals that affect man are so great that any selection made will be inadequate.

For the purposes of this book, however, only a few outstanding examples will be given, the selection being made as practical as possible. Emphasis will be placed upon how man may avoid becoming infected. In this section of the chapter no attention will be paid to symptomology and treatment, those being considered to be medical problems.

Tularemia. Tularemia is an outstanding disease of wild rabbits and numerous other mammals. It is of bacterial nature, caused by *Bacterium tularense,* and is widely distributed over the United States. Infection ordinarily takes place by allowing a cut, scratch, or wound to come in con-

tact with a diseased animal. Being injured by a splinter of bone while dressing a diseased rabbit is perhaps the most usual way of acquiring the infection. But biting flies, notably the deer fly and ticks, especially the rabbit tick, are also sources of infection. Tularemia in humans is a debilitating disease; and since the mortality from it is approximately 5 per cent, one should not take unnecessary risks such as handling animals that may have the disease. The highest incidence of infection is ordinarily in late summer and early fall. Deferring the rabbit-hunting season until late fall and winter is perhaps good antitularemia insurance for the hunter.

Rabies. Rabies, a deadly virus-caused disease, is transmissible to man through the bite of a rabid animal, usually a carnivore such as a dog, fox, coyote, or skunk. It is regarded by medical men as being incurable and 100 per cent fatal when Pasteur treatments have not been administered and when once it has become established. However, prompt treatment with the protective inoculation is almost 100 per cent effective. This treatment consists of a series of inoculations extended over a period of time. Protection of dogs against rabies is widely practiced, the treatment consisting of a single inoculation only but requiring to be repeated every year. For reasons too complicated to be discussed here, rabies vaccination in dogs is not 100 per cent efficient, and that is one of the reasons why we continue to have rabies even in areas where all dogs are vaccinated. Many veterinarians are now advocating a series of inoculations of the antirabies vaccine for protecting dogs to bring the preventive treatment more in line with the proved superiority of the human inoculations. Of course, the presence of rabies in wild carnivores is a contributing factor. It is highly probable also that many cases of rabies in dogs develop so slowly with the symptomology so inconspicuous that one has no forewarning of the possible danger from these animals.

Plague. Plague is a dangerous bacterial disease that has scourged humanity throughout the ages. Its persistence is due to reservoirs of infection in rodents. The intensity of the disease in rodents varies from time to time and place to place, owing to the nature of the immunities that develop. Transmission to man is through the bites of fleas that have previously fed on infected rodents. Rodents nearly always harbor fleas, so one should always take precautions against being bitten by fleas.

Rocky Mountain Spotted Fever. Rocky Mountain spotted fever is a rickettsia disease of man, highly dangerous and often fatal, against which every precaution should be taken. Contrary to popular belief, it is not restricted to the northern Rocky Mountain regions. It is tick-transmitted and is of great interest to wildlife management because so many different kinds of animals may be involved in its perpetuation. The reservoirs of infection are various species of ground squirrels. Ticks feed on these animals, drop off and molt, and may then attach themselves to large game

mammals and get a long ride, particularly if the animals have migratory habits from winter to summer range. The engorged ticks that are females drop off and lay 3,000 or more eggs, which retain the infection, passing it on to the larval ticks that hatch from the infected eggs. At any stage in the life history of the tick, it is infective to a human if it carries the infection of Rocky Mountain spotted fever.

If one has occasion to be in the field in infested tick territory, he should first of all receive the necessary "tick shots" that are available without cost through the local offices of the U.S. Public Health Service. One should be cautious and if ticks get on him, remove them before they attach themselves.

MISCELLANEOUS PATHOLOGICAL CONDITIONS

In the preceding pages disease and parasitism have been considered largely with respect to specific diseases of parasites and specific hosts. A few examples will now be given that have more generalized application.

Following the drought years of 1934 and 1935, when many carloads of western livestock were brought into some of the Southern states, it was noted that shipping injuries and injuries easily suffered by the animals in their new environment of wooded rather than open country became generally infected with screw worms, the larvae of certain species of flesh flies. To be sure, flesh flies had been known for a long time in livestock in the South, but it was not generally on record that many kinds of wild animals in that section of the country were similarly affected by the same kind of flesh flies. It required a spectacular situation such as the mass movement of livestock to call attention to something that ordinarily escaped notice.

In the earlier stages of the western duck sickness, investigators were constantly looking for some all-inclusive cause that could account for the observed mortality of waterfowl. To be sure, other birds were sick and dying from botulism as well as from other causes, but the general public was not much concerned. We now know of many factors that can and do cause mortality in waterfowl and other birds at various times and places and realize that mortality, although it may be selective, may be due to parasites that are peculiarly fatal to the young, to the adult, to the senile; to botulism, which affects all age classes; to selenium poisoning, which affects all age classes; to drought, which deprives the young of a suitable environment in which to spend their early juvenile days; or to predators that can get in their work only if certain other contributory causes are operative. So we close this chapter on disease hoping that it will stimulate the wildlife manager to be continuously on the alert and always try to understand the complexities of disease and parasitism in wildlife to the end that he will not advocate impossible and impractical procedures.

LITERATURE ON ANIMAL PATHOLOGY

A short list of books, journals, and references to periodical literature is appended as source material for the student who is not content with merely reading an assigned chapter in a textbook.

Original papers on diseases of wild animals are widely scattered among medical, veterinary, and other professional and scientific journals. Of books usually available in college libraries, the following is a minimum list:

Becker, Elery R. 1934. Coccidia and coccidiosis of domesticated game and laboratory animals and of man, Collegiate Press, Inc., Ames, Iowa.

Feldman, William Hugh. 1938. Avian tuberculosis infections, The Williams & Wilkins Company, Baltimore.

Fox, Herbert. 1923. Disease in captive wild mammals and birds; incidence, description, comparison, J. B. Lippincott Company, Philadelphia.

Hull, Thomas Gordon. 1941. Diseases transmitted from animals to man, Charles C. Thomas, Publisher, Springfield, Ill.

Mönnig, H. O. 1938. Veterinary helminthology and entomology, William Wood & Company, Baltimore.

Runnells, Russell A. 1938. Animal pathology, Collegiate Press, Inc., Ames, Iowa.

Simpson, Walter Malcolm. 1929. Tularemia; history, pathology, diagnosis and treatment, P. B. Hoeber Inc., New York.

U.S. Department of Agriculture. 1942. Keeping livestock healthy. *Yearbook*, Washington.

The U.S. Department of Agriculture *Yearbook* is extremely practical and comprehensive. It, as well as the others listed, is valuable for its hundreds of references to original literature and for the numerous excellent illustrations. The student of animal pathology should also make use of abstracting journals such as *Biological Abstracts* and the *Experiment Station Record*. Since there is no sharply drawn line between wild-animal diseases and diseases of domesticated animals and humans, he should also become acquainted with these fields of knowledge.

Of the veterinary journals published in English, the following are usually available in college libraries:

United States and Canadian:

American Journal of Veterinary Research
Canadian Journal of Comparative Medicine and Veterinary Science
Cornell Veterinarian
Journal of the American Veterinary Medical Association
North American Veterinarian
The Iowa Veterinarian
Veterinary Medicine

British:

The Veterinary Journal
The Veterinary Record
Veterinary Bulletin

SELECTED LIST OF CURRENT LITERATURE

1. CLARKE, C. H. D. 1935. Blood parasites of ruffed grouse (*Bonasa umbellus*) and spruce grouse (*Canachites canadensis*), with description of *Leucocytozoon bonasae* N. sp. *Canad. Jour. Res.* **12**:646–650.
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3. GOBLE, FRANS CLEON. 1941. Tissue changes in white-tailed deer (*Odocoileus virginianus borealis*) accompanying natural infections of lungworms (genera *Protostrongylus* and *Dictyocaulus*). *Jour. Wildlife Mangt.* **5**(2):141–158.
4. KALMBACH, E. R., and MILLARD F. GUNDERSON. 1934. Western duck sickness: a form of botulism. *U.S. Dept. Agr. Tech. Bul.* 411.
5. KATES, K. C., and D. A. SHORB. 1943. Identification of eggs of nematodes parasitic in domesticated sheep. *Amer. Jour. Vet. Res.* **4**(10):55–60.
6. KEANE, CHARLES. 1926. The epizootic of foot and mouth disease in California. *Calif. Dept. Agr. Spec. Pub.* 65.
7. LAAKE, E. W., EMORY C. CUSHING, and H. E. PARISH. 1936. Biology of the primary screwworm fly *Cochliomyia americana*, and a comparison of its stages with those of *C. macellaria*. *U.S. Dept. Agr. Tech. Bul.* 500.
8. O'ROKE, EARL C. 1934. A malaria-like disease of ducks caused by *Leucocytozoon anatis* Wickware. *Mich. Univ. School Forestry and Conserv. Bul.* 4.
9. SHILLINGER, J. E., and L. C. MORLEY. 1937. Diseases of upland game birds. *U.S. Dept. Agr. Farmers' Bul.* 1781.
10. SKIDMORE, LOUIS V. 1932. *Leucocytozoon smithi* infections in turkeys and its transmission by *Simulium occidentale* Townsend. *Zentbl. f. Bakt.* Abt. I, Originale. **1**(125):329–335.
11. TYZZER, ERNEST EDWARD. 1927. Entero-hepatitis in turkeys and its transmission through the agency of *Heterakis vesicularis*. *Proc. 3d World's Poultry Cong.* Pp. 286–290.
12. ———. 1929. Coccidiosis in gallinaceous birds. *Amer. Jour. Hyg.* **10**:269–283.
13. ———. 1934. Studies on histomoniasis or blackhead infection in the chicken and turkey. *Proc. Amer. Acad. Arts and Sci.* **69**:189–284.
14. ———, HANS THEILER, and E. ELIZABETH JONES. 1932. Coccidiosis in gallinaceous birds. II: A comparative study of species of *Eimeria* of the chicken. *Amer. Jour. Hyg.* **15**:319–393.

Section IV

MISCELLANEOUS WILDLIFE RELATIONSHIPS

CHAPTER XXV

VARIATIONS IN NUMBERS OF WILD ANIMALS

GENERAL

A complete summary of the data on numbers of animals and the factors that affect variations in numbers would take more space than can be allotted here. To ignore the subject completely, however, would leave a gap covered by no other part of the book. Therefore, a brief discussion of this important part of wildlife management will follow. The reader is advised to study the material by Elton (*37 g.r.*) and others for a more complete and detailed treatment of the subject.

FACTORS INFLUENCING THE NUMBERS OF WILD ANIMALS

A variety of factors and influences determine the numbers of animals in any locality at a given time. These include soil fertility, available food, the stage in the succession of plants, the variety of animal species present, the biotic potential of each species, and the factors of resistance to each species.

The fertility of the soil in any location is the basic determinant of its capacity to produce plants and animals, taking for granted, of course, that other factors such as climate are favorable. Included in fertility must be considered the texture of the soil, for smallness of rock particles determines the availability of minerals contained in them. The amount of available water is also a major factor in plant growth. Barren, desert lands often need only irrigation to make them productive. At the other extreme soils with too much water are unproductive of emergent plants.

Rock must go through a series of changes before it reaches its highest productivity. Its chemical make-up broadly determines what plants can grow on soils derived from it. Then as the plants succeed each other from the simple lichens toward the higher forms, the rate of breakdown of the rocks and of organic matter accumulation increases. Somewhere within the plant succession from lichens to climax forest a point is reached where the production of animals is greatest. This point is somewhat short of the

climax and varies with the animals involved, each species having a rather rigid set of environmental requirements. Likewise maximum production of animal life may be a confusing term unless clearly defined in terms of weight or numbers. A case in point is the number of ants an environment will produce as compared to the number of vertebrates such as mice or rabbits. Total weights may be quite comparable, but numbers are greatly in favor of the ants.

Biotic potential of a species is defined as "the inherent ability of an organism to reproduce and survive, the maximum rate of increase. It depends on the number of young produced at each reproduction, the number of reproductions in a given period of time, and the sex ratio of the species" (*54 g.r.*).

Biotic potential is only one of the determinants of a total population. It does, however, set the upper limits of the rate of increase for a particular species. The actual numbers of animals present in a given place are also dependent on the factors that retard reproduction or destroy some of the animals. These factors are classified as a group under *environmental resistance*.

Environmental resistance is "the sum of all factors of the environment that tend to reduce the number of . . . animals before the maximum that would occur should the biotic (reproductive) potential be realized."

Thus in any environment there are two sets of opposing forces constantly at work. As one or the other gains dominance, the population rises or falls. When the opposing forces are in balance, the population is static.

One of the factors of environmental resistance is the take by man. This is commonly cited as the dominating condition in keeping populations of game low, and, of course, this conclusion may be a fact. It is not always the case, however, as other basic factors of production may be keeping the numbers of animals low.

SPECIAL TYPES OF ANIMAL CONCENTRATIONS

As pointed out by Hamilton (*51 g.r.*) populations of all types of animals are noticeably unstable, fluctuating from year to year and even from season to season. Rabbits and hares may be abundant in a given area for a series of years and scarce during other periods. Certain migrating animals may be relatively scarce locally; but when the production of a specific animal from an entire continent gathers in a limited area, as with some of the waterfowl, the numbers may appear unusually great. Outbreaks of mice have been known throughout Europe for centuries (*39 g.r.*), and descriptions of the enormous numbers of the passenger pigeon and bison are historical facts for the eastern hardwood region and the central grassy plains of the North American continent (*40 g.r.*).

Uvarov, quoted by Hamilton (*51 g.r.*), points out that the *balance of nature* so commonly spoken of by the layman is a myth and that fluctuations are the rule, not the exception.

The question may well be asked, "What regulates the production and survival of animals?" In the case of an animal that breeds once a year, as do many of the large ungulates, the numbers are high at the time the young are born but are steadily reduced until reproduction again occurs the following year. On the other hand, the animals that give birth to young more than once a year usually mature quickly, and their rate of increase during the breeding season is great, as new members of the population in turn give birth to young. During the season when breeding is quiescent, the population trends are downward. Under conditions where the food supply is plentiful and where the numbers of animals lost during the nonbreeding season do not equal or exceed the numbers of animals produced, the population increases, sometimes resulting in unusually high population densities. In cases where a population destroys its food supply or if for other reasons excessive numbers of animals are detrimental to the population, the population declines from higher to lower numbers.

CYCLES

As already pointed out, fluctuation in numbers of an animal population in any locality that reaches such proportions as to attract attention because of excessive numbers followed by a noticeable scarcity of the same species is said to be cyclic. This designation has led to the belief by the layman that cyclic behavior of animals is a pulsation with the same regularity as such natural phenomena as phases of the moon or the ebb and flow of ocean tides. This imagined regularity of the time and degree of cyclic changes does not hold true, of course, since an animal population may not reach the same degree of high or low density during consecutive periods. Furthermore, there may be secondary changes that, represented graphically, cause a series of peaks and depressions rather than a smooth oscillating line.

Elton (*37 g.r.*) describes a cycle of animal abundance and scarcity as follows:

> It should be sufficiently clear by now that the numbers of many animals are subject to great fluctuation from year to year and that in the majority of cases which have been investigated, these fluctuations can be traced ultimately to pulsations or changes in the environmental condition affecting the animals.

Leopold (*66 g.r.*) describes a cyclic species as one that fluctuates over 50 per cent in number from normal density. Fluctuations of a species would obviously need to extend over much of its range to be considered cyclic.

Concerning its operation, a discussion of cycles can be divided into a number of question and answers, namely,

What animals are affected?

Are cycles similar in duration and degree?

Does the cycle operate to the same degree in all localities?

What causes the building up or increase in numbers, and how long does it take?

What causes the crash or decrease, and how long does it take?

How does it affect different sexes and age classes of animals?

The following paragraphs will attempt to answer these questions as disclosed by the published literature and data on the subject.

Animals Affected by Cyclic Fluctuations. Many species of insects are cyclic under the definition as given. Some are not. Among the higher animals, cycles of voles and the lemmings have been conspicuous and have caused much economic loss to man in destroying crops or because of conspicuous activities such as large numbers of animals appearing in locations where they were not commonly found previously (*39 g.r.*). The lemmings and meadow mice are cyclic in at least parts of their ranges in North America.

Cyclic conditions of varying hares in North America have probably always occurred. These have caused great suffering to the Indians because of the alternating abundance and scarcity of food and blanket material furnished by the hares, also because of the fluctuation in numbers of the fur-bearing animals that prey on the hares. These cycles have had a marked effect on numbers of fur bearers and the fur take throughout Canada for over a period of 300 years.

According to Hamilton (*51 g.r.*), jack rabbits are cyclic in Minnesota, but not in Arizona. Cottontails also are cyclic as far south as Missouri. However, cycles are more severe in Wisconsin and Michigan, particularly on ranges acquired since man changed the type of cover and helped the cottontail advance into habitat formerly not occupied by this species. The length of the low population period of the cottontail rabbit is not more than a year in the southern part of its range, but periods of scarcity are longer further north (*65 g.r.*).

The period of cyclic abundance and scarcity for ruffed grouse has received much attention, because during the early history of this country the bird was an important source of food in the eastern part of the United States and later because of its importance as a game bird. Both pinnated and sharp-tailed grouse are subject to violent cyclic disturbance in the Lake states according to Leopold (*65 g.r.*), a condition also probably true in Canada and Alaska.

Types of Population Curves and the Nature of Cycles. Leopold (*65 g.r.*) gives three general types of population curves as representing different

variations in animal numbers. These are the flat type, the irruptive type, and the fluctuating type. The flat type is described as a condition in which there is very little change in the population from year to year. Bobwhite quail in the southern part of the range would come under this designation. The irruptive type is a condition of animal numbers that follows a uniformly low density for a number of years but under favorable environmental conditions builds up to a high point during a favorable breeding year. The bobwhite quail in the extreme northern part of its range on very fertile soils of the Lake states would follow this type of population curve. The fluctuating type of population builds up over a period of years, then is reduced to a low point during a succeeding series of years. The ruffed grouse follows this type of fluctuation behavior throughout the northern part of its range.

Time phases of cycles are difficult to determine. The difficulty lies in determining when the same point of the cycle recurs. For example, a low during one cycle may not be so low as it is during another cycle. However, if the year of occurrence of several lows or highs is recorded, the average time of a cycle can be closely approximated by dividing the total years by the number of cycles. Table 70 that follows gives the average length of cycle for various species.

TABLE 70. LENGTH OF CYCLIC FLUCTUATION FOR CERTAIN WILD ANIMALS

Name of animal	Cycle length, years	Authority
Lemming (*Lemmus* sp.)	3+	(*39 g.r.*)
Field mice (*Microtus* sp.)	4	(*51 g.r.*)
Varying hare (*Lepus americanus*)	8–11 *	
Muskrat (*Ondatra zibethica*)	10	(*66 g.r.*, *37 g.r.*)
Gray squirrels (*Sciurus carolinensis*)	5–10	(*37 g.r.*)
Ruffed grouse (*Bonasa umbellus*)	10+	(*66 g.r.*, 5)
Pinnated grouse (*Tympanuchus cupido americanus*)	10+	(*66 g.r.*)
Salmon and cod, Atlantic coast (*Salmo salar* and *Gadus collarias*)	10	(*66 g.r.*)

* LLOYD, HOYES. 1936. The late Norman Criddle's record of the snowshoe rabbit (*Lepus americanus*) at Aweme, Manitoba. *Canad. Field Nat.* 50 (8):129–130.

Data on the degree of fluctuation of the cyclic phenomena are more difficult to compile than are data on the time when periods of abundance and scarcity occur. Hamilton (*51 g.r.*) gives the variation in numbers of jack rabbits on a square mile from a few during a low to 69 during a high. This difference in numbers may not be constant for the same location, however. According to Criddle (*7 Varying Hare*), the varying hare may reach a low of 64 per square mile during a low and 3,200 for the same area during a

high. Green *et al.* (*11, 12, 13 Varying Hare*) found a high of 500 snowshoe hares per square mile in February, 1933, and a low of 32 animals per square mile 5 years later. The number of ruffed grouse may fluctuate from 6 to 8 per square mile for early spring during the low to 50 or more for the spring season during the high. These data may hold for one location, but not for another.

Hamilton (*51 g.r.*) states that field mice may vary from a low of one or two dozen per acre to several hundred per acre during the high of the cycle. During a mouse outbreak in California, the numbers at the height of the outbreak were estimated at 80,000 per acre, but this probably should be more correctly termed an irruption rather than one of the phases of a cycle (*39 g.r.*).

A knowledge of years of high and low phases of cycles is important for historical as well as for management purposes. It is obvious that exact dates cannot always be given, as these may vary in different parts of the North American continent and also for Europe. Years of abundance and scarcity for ruffed grouse in the north-central part of the United States are given as follows:

Abundant	Scarce
1880–1883 (5)	1884–1885 (5)
1887–1889 (5)	1895 (*65 g.r.*)
1892 (5)	1899 (*65 g.r.*)
1901 (5)	1907–1908 (5)
1911–1913 (5)	1917 (5)
1919–1924 (5)	1927–1930 (5)
1931–1933 (5)	

Years of varying hare abundance on the Hudson Bay watershed in Canada as given by MacLulich (*15 Varying Hare*) are 1856, 1864, 1875, 1886, 1895, 1914, 1924, and 1934.

Leopold (*65 g.r.*) indicates that the British grouse cycle ranges in length from 4 to 8 years and averages about 6.5 years. It may be from such data that the common notion of a 7-year grouse cycle originated. The length of the cycle of game birds, rabbits, and hares is about 10 years in North America and is not synchronized with the British cycle for similar species of wildlife. The fur-bearer cycle in Canada parallels that of grouse and rabbit with the exception of the muskrat cycle, which is inverse to it.

The Mechanics of the Build-up. The "build-up" of an increasing animal population is usually a slower process than the decline. An example of a rapid build-up is illustrated by the population curve given by Leopold (Fig. 5, *66 g.r.*) as an irruptive curve, where some of the environmental pressure is removed from a normal but low population on a naturally productive range. Under these conditions nearly all the offsprings of a season may survive and an abnormally high population develop. Under

favorable conditions the bobwhite quail in Michigan, Wisconsin, and Iowa may follow this type of population behavior.

The mechanism of the build-up of animal populations has been sought, but few accounts of how it operates have been published. Hamilton (*51 g.r.*) gives an excellent account of the mechanics of a "build-up" of the meadow mouse during its 4-year cycle, which is quoted here:

Following a drastic decline in numbers, sometimes as much as 80 per cent, the species begins to recover its numbers. Because there are fewer mature individuals, there is less opportunity for mating among these promiscuous voles, and as a result there are fewer litters in a season. Moreover, for unexplainable reasons, the number of young per litter is rather small, and the breeding season seldom lasts longer than seven months. If winter conditions are favorable, the breeding stock during the following spring is measurably larger than that of the previous spring. Reproduction may commence a week or ten days earlier; larger litters are produced; and because of the increased number of mature mice, a greater likelihood of mating is afforded. Thus, the litters succeed one another more rapidly. The breeding season is prolonged, possibly extending into early November. The same events follow the next year, except that every phase is accelerated. Finally, the fourth year of the cycle finds great numbers of mice, all fecund and ready to breed. The season of reproduction may carry through the winter, so the young are produced in the coldest months, although the litter size at this season is reduced. Collett states that the young of lemmings born in the prolific years are possessed of greater powers of attaining maturity and resisting disease than are those born during a "normal" year. Finally, a pandemic occurs, which stalks through the ranks, taking a large share of the population in a very short time, often a matter of but a few weeks. The greater the density of the population the more drastic the decline.

The length of time required for a population to build up depends upon the species concerned. Populations of short-cycle species like the meadow mouse build up for 3 or possibly 3½ years, while the varying hare may take from 5 to 7 years (*11, 12, 13 Varying Hare*).

The Causes of the "Crash" in Animal Populations. The causes of the "crash," or decline, in animal populations are probably many. The devastating agent may attack in any of a variety of ways, depending on the point of greatest vulnerability. It may operate at any time of year and on any or all age classes. Smith and Cheatum (15) state that cottontail rabbits on Fisher's Island, New York, died of (1) tick-induced anemia or (2) bacterial infection at points of tick attachment which results in localized infections of the lymph glands. Also, juvenile losses occurred (1) when nestlings were abandoned by sick or dying female rabbits or (2) when burdened with fatal infestations of ticks after leaving the nest.

One of the main causes of the "die-off" of varying hares in Minnesota according to Green (*14 Varying Hare*) is from shock disease, a condition of low sugar content of the blood. The observations by this investigator

indicate that death may occur during any season of the year and that both adults and juveniles may succumb to the malady. A later study,[1] however, showed that the rise and fall of the hare population depended on the degree of mortality among the young hares. When fewer than 30 per cent of the young survive to February, the population will decline; when more than 30 per cent survive until February, the population will increase.

Braestrup (4) gives the cause of shock disease as a lack of minerals in the diet.[2]

One of the very worth-while contributions to the study of cyclic phenomena is the information contributed by Cartwright (6) in an explanation of the cause of the "crash," or decrease, of the sharptailed grouse and Hungarian partridge in western Canada. Losses of first clutches were due to below-normal temperatures and above-normal precipitation in certain parts of southern Canada during 1942 and 1943. Cold, wet nesting seasons are known to be destructive to gallinaceous broods. As the fall composition of gallinaceous birds is normally 70 to 80 per cent young of the current season, excessive losses of young materially reduce the fall population and completely eliminate the population in a 3-year period provided second nesting attempts also are not successful. All the conditions for a sharp reduction, or crash, seem to be present in the situation as described by Cartwright. Sharptail and probably Hungarian partridges have a life span of about 3 years. In the fall seasons of 1942–1943 in southern Canada examinations of birds in hunter's bags and in cold storage showed that very few juvenile birds were shot during the gunning season. There were some juveniles, however, probably due to renesting after failure of the first broods. Loss of the current crop of young birds is one process by which the crash of a cycle may occur.

Cartwright (6) carried his conclusions still further in relation to the value of predators in saving gallinaceous birds from extinction. When some of the first nests are destroyed, these birds will be caused to renest and are likely to hit more favorable conditions than those found during the earlier attempt. Thus, a limited amount of predation preserves a species, because the remnant is able to recover later and repopulate the range. This may be called "Cartwright's principle." Cartwright points out that whereas a limited number of predators are beneficial to land-nesting birds, they are detrimental to waterfowl because in the latter case dry weather may destroy the habitat as the potholes dry out later in the

[1] Green, R. G., C. A. Evans, and C. L. Larson. 1943. A ten-year population study of the rabbit tick *Haemaphysalis leporis palustris*. Amer. Jour. Hygiene, **38**(3):260–281.

[2] Professor Ralph King suggested the relationship of the nutritional properties of newly grown browse to the "die-off" of ruffed grouse in a paper presented at the 1936 American Game Conference. This paper was not published in the *Proceedings*, however

season. This would prevent a second nesting such as may occur with land birds. With waterfowl the lack of water may be lethal.

Little evidence is available in the literature as to the differential effect of predation, disease, and exposure on males and females. With fish, counts of large numbers seem to indicate that the females are more resistant to adversity than are the males. Thus in a study of yellow perch 296 females were found for every 100 males.[1] With birds, however, the males are more resistant, as is indicated by the preponderance of males in the continental population of waterfowl. It is an accepted belief among grouse hunters that ruffed grouse shot during the low of the cycle are mostly older birds and are largely males. Figures to substantiate this belief are not available. If it is true, it would account for the slow "build-up" of the grouse population after a crash. With mammals there is some indication that the female is more resistant than are the males. In the case of mammals the discovery by Gerstell (*39 Deer*) that the sex ratio of white-tailed fawns is unbalanced in favor of females under conditions of poor nutrition seems to bear out the theory. Life-expectancy tables for male and female human beings also bear out the theory for mammals.

The sunspot theory in relation to animal fluctuations becomes clearer as more data accumulate. Let us compare the statements of an astronomer (2) in relation to sunspot cycles with that of two biologists in relation to cycles of the ruffed grouse (5) and the varying hare (*15 Varying Hare*).

Andrews (2) states

> . . . variation of spottedness of the sun possessing a period of 10.8 years, or, as one commonly states it, a period of 11 years. A further perusal of the table—and it lists the maxima and minima back to 1610—reveals that this period is not reproduced with clocklike precision. One notes a minimum interval of 7.3 years and a maximum interval of 15.0 years. In fact the long-term average for the period of sunspot variation is 11.13 years.

Compare this with what Bump (5) states about the ruffed grouse cycle.

> On the basis of present records, the median of periods of abundance may fall from 8 to 13.5 years. The span for five of these intervals is 10.1 years on the basis of mid-central continental records. Present data from the Northeastern states would suggest the average distance between four median periods of abundance to be 12.2 years. . . .

MacLulich (*15 Varying Hare*) gives the length of the cycle for snowshoe hares as varying from 8 to 11 years, with the average length of eight cycles as 9.6 years.

Andrews (2) indicates that the years of high sunspot activity bring

[1] Hile, Ralph, and Frank W. Jobes. 1940. Age, growth, and production of the yellow perch *Perca flavescens* Mitchell of Saginaw Bay. *Trans. Amer. Fisheries Soc.* **70**:102–127.

increased heat radiation to the earth. Related to this greater heat radiation are greater evaporation on the surface of the earth, greater precipitation (including greater snow depth), and cooler conditions resulting from the higher evaporation and precipitation (condensation).

Could the cause of cyclic behavior in some species be related directly to cooler summers and colder winters, and could more moisture in the form of both rainfall and snowfall be a contributing factor to the reduction of nests of Hungarians and sharptail in southern Canada (6)? Could colder winters with unusual depths of snow in Wisconsin create lethal conditions for bobwhite quail on the northern edge of the range (*28 Bobwhite Quail*)? Could exceptionally heavy rains drown the entire crop of young cottontail rabbits during the peak of a nesting season while these are still nestlings (*39 Cottontail Rabbit*)? Could a condition of less than average moisture between the periods of high sunspot numbers account directly for the drying out of ponds and the subsequently lower production of muskrats, poorer duck-rearing conditions, and the reduction of spawning areas and intolerant spawning conditions for the Atlantic salmon? These are all academic questions having practical implications that will require much detailed study and factual data before any more positive assertions can be made.

No simple explanation for the relation of sunspot maxima and minima to shock disease in varying hares or the blood disease (*Leucocytozoon bonassae*) of ruffed grouse is at hand, but the relationship of increased ultraviolet light, together with cooler conditions and greater rainfall, may hold the answer.

A curtain of mystery still obscures a clear view of how the rise and fall of animal populations occur and why animals unrelated in form or physiology are affected. The answers to many of the perplexing questions are still being sought, but at least some clews to these problems have been found, such as the following:

Cycles differ in length of time, depending on the size of the animals.

Cycles are more pronounced in the zone of severe cold climates where snow is present part of the year than where warm seasons without snow are continuous and milder weather prevails.

Herbivores are more subject to cyclic changes than are omnivores.

Animals that can control their environment to a limited degree and consume more than the current plant growth, such as the beaver, are less subject to cycles than those which have no control over their environment.

Cycles are not the results of basic changes in the breeding mechanism such as the number of young in a clutch or litter or the number of litters. The crash occurs when a high proportion of the yearly increment is lost, such as the eggs of birds and the young of mammals.

Carnivores respond to variations in their food supply rather than being the cause of the variation in the number of prey.

Lastly, the force that controls the various cycles may be a cosmic force, but as yet its relation to the secondary cause or causes of mortality has not been satisfactorily explained.

The theory of the control of cycles by cosmic forces is not entirely without foundation. The presence of cyclic phenomena over areas as extensive as a continent would seem to indicate that the control of the decimating agents is by cosmic forces. Cycles on disconnected ranges, as on islands, for example, appear to be synchronized with the phenomenon on the mainland, a condition that seems to strengthen the cosmic-control theory.

Some evidence, however, indicates that the causes or controls of animal cycles are not cosmic. Clarke (*11 Ruffed Grouse*), Elton (*39 g.r.*), and others show that the lengths of cycles of different animals vary: 3 years for lemming, 4 years for meadow mice, 9 years for varying hare, and 10 years for ruffed grouse. Clarke also indicates that the beginning of the diminution in numbers may extend over a number of years, sometimes equal in time to at least half of the periodicity of the cycle.

Clarke's work also shows that a particular stage of a cycle does not appear simultaneously over the continent but is a progressive march from northwest to southeast. This again does not fit with the cosmic-control theory.

Cycles and Management. The cyclic nature of some game animals, namely, ruffed grouse, sharp-tailed grouse, and prairie chickens, has retarded efforts to manage them intensively, the contention being that it is not logical to expend efforts on a resource the returns from which are uncertain. One is led to suspect, however, that as long as a fair volunteer crop is available part of the time, the American hunter is not willing to spend money to produce a better one. Lack of knowledge of the real nature of cycles has probably been most responsible for this reluctance to attempt to manage cyclic wildlife species.

Leopold (*66 g.r.*) points out that cyclic species of grouse in Great Britain have been managed successfully and suggests that there are attractive opportunities to manage American grouse, especially the prairie chicken. Specific management practices for each species are suggested under the different chapters. A general recommendation that will bear repeating here relates to hunting. The cycle reduces the entire population, but in the case of the ruffed grouse, varying hare, Hungarian partridge, sharptail, and cottontail the reduction is mainly a decrease in the current crop of young animals. The population is still further reduced by hunting, which probably removes a considerable proportion of the individuals that would otherwise survive and serve as the breeding reserve. If hunting of

these cyclic species could be entirely eliminated during the years of low numbers, it would probably accelerate the "build-up." Likewise, the improvement in amount and quality of food and the reduction of predatory and other losses also should assist a low wildlife population in making a more rapid recovery.

It should be remembered that such practices may not influence the length of the cycle or in any way reduce the extent to which the population curve declines. It should, however, make the curve of recovery steeper and perhaps thereby increase the number of shootable individuals during the period of recovery.

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CHAPTER XXVI

PREDATOR-PREY RELATIONSHIPS

GENERAL

The complex relationship between flesh-eating animals and their prey has long been misunderstood, and many crimes have been committed in the name of conservation against the carnivorous animals. This chapter will attempt only to classify some of the problems relating to predaceous creatures and to give some opinions as to the effects of predator control.

Man himself is predaceous, so the indignation that is often registered against predaceous animals does not stem from a revolt against the taking of a life as such but rather from pure selfishness. Thus, when a hunter sees a hawk kill a pheasant, he is probably resentful not because the pheasant has been killed but rather because the hawk has killed a game bird that he himself wanted to bag. Nor is this peculiar emotional trait limited to hunters and fishermen. Many organizations of so-called "nature lovers" advocate the principle of the preservation of all life but at the same time condone the killing of one species of animal, such as a hawk, because of the latter's supposedly cruel method in the disposing of its prey. Either of these points of view can be in error because of the ultimate effect that the killing of one species may have on the total animal population of a locality. The reasoning that if one removes a predator, the population of its prey will increase is often fallacious. This is well illustrated by Fisher in the *Yearbook of Agriculture for 1908* (*51 g.r.*) in describing the ecology of a marsh in northern New York. Originally this marsh harbored numerous waterfowl and other aquatic life, including snapping turtles. Skunks fed on the eggs of the turtles and thus kept their numbers in check. The high prices of furs resulted in the trapping out of the skunks, thereby allowing the turtles to increase. The increased turtle population fed on ducklings, which resulted in almost total elimination of the waterfowl. A subsequent change in the price of fur allowed the skunks to again increase, with the result that the turtles were reduced and the ducks came back.

Biological events of this type are not unusual but can occur wherever wild animals exist. The blundering activities of man, which attempt to increase one animal by reducing another, may unbalance the entire wildlife population of an area and produce the opposite result from that desired. Much mismanagement has resulted from a lack of knowledge of the food

of a predaceous species or from only a partial knowledge of the relationships of several species. Predator relationships are complex and cannot be dealt with as simple phenomena. Gabrielson (*42 g.r.*) gives an excellent discussion of the various conflicts of predators and man with some conclusions that appear sound.

These basic principles are as follows:

1. Under normally stabilized conditions over a wide range, predators generally live upon surplus populations of prey species, and their activities in the aggregate have little or no effect upon the breeding stock needed for the succeeding season. Local adjustments in accordance with varying conditions are often desirable to maintain a balance, though this can never be perfect; the observed *average* stability of animal populations emphasizes this point.

This principle of predators living on surpluses can well be called "Errington's principle" (6, 7). As explained by Errington, it shows conclusively that a given habitat has a certain fixed capacity under average weather conditions and that any surplus beyond this capacity will be lost either to predators or in some other way. A knowledge of this principle will emphasize the need on the part of the wildlife manager to use money and labor to improve the habitat rather than to expend his efforts in fruitless attempts to destroy predators. Much money and effort are now spent in restocking ranges that are suited to only a low carrying capacity of game. Costly breeding stock is released and then lost to predators or destroyed by weather, disease, or other agencies. Too frequently it is not recognized that inadequate range rather than predators or other decimating agencies is the true cause of the losses.

2. Under special conditions, either favorable to the predator or unfavorable to the prey, predators may become a real factor in decreasing populations or in preventing recovery following a decline in a population.

As an illustration of this condition Riter (17) describes a case where antelope reached a low ebb in numbers in an area bordering on California, Oregon, and Nevada. Under complete protection from hunting, the herd remained low in numbers and did not increase until the numbers of bobcats and coyotes were reduced. Following this decrease in the number of predators the antelope herd increased from 500 to 7,000 or 8,000 in numbers. After the increase of the antelope, the pressure of predators had little effect on the herd. Such a condition takes for granted the presence of an environmental condition that is suitable for increased numbers of the desirable species.

3. The effect of predation upon populations is more evident when the predator is a more prolific species than is the prey. Where the reverse is true, the effect is at least obscured by the fact that the victim has a greater reproductive capacity than the predator.

The author believes that this principle is not a matter of simple dynamics of two species but a virtual maze of ecological interrelationships. For instance, cats are faster breeders than sparrows, yet the fluctuations of a sparrow population depends not primarily on the predaceous activities of cats but also on the amount and suitability of food and cover and other environmental factors.

Where the prey has a greater capacity to breed than the predator, it appears there is little danger of the number of prey being dominated by predation, although the numbers of the predator population will fluctuate with the changes in numbers of the prey species. This is well demonstrated by the effect of the cycles of varying hare on bobcat and lynx populations.

4. Generally, the agency of predators in reducing large populations is minor compared with the more vital one of available food, the supply of available cover, the correct interspersion of these two essentials, and disease. Any one of these or factors unknown may be more effective than predation in limiting numbers.

This general concept is well authenticated by the studies on various game species made in different localities. Excessive predation means a weak habitat. This applies to the bobwhite quail in both the Southeast and Lake states, ducks in the Dakotas, and pheasants throughout their range.

5. Human interests, primarily economic, will always be paramount; and when domestic animals are involved, it is useless to explain it (*i.e.*, the biological situation) from the purely biological point of view. If domestic-animal populations alone were concerned, predation on herds or flocks might not result in a serious or abnormal decrease, but the economic factors involved and the sociological effects preclude a purely biological approach to the problem.

It matters not whether foxes in New Hampshire take only one-thousandth of 1 per cent of the chickens on the farms or if the grizzly bear kills only a hundred of the millions of cattle on the western ranges. The loss of one-thousandth of 1 per cent of the poultry may be the difference between a profit and loss for one grower, and the loss of one hundred cattle may prevent the payment of a note by a western rancher. In the conflict between wildlife aesthetics and bread and butter, wildlife must yield.

6. The numerical ratio of game animals and game birds to their natural predators may be disturbed when human hunters in large numbers enter the field. Utilization of the game crop by man, therefore, may necessitate some reduction in numbers of predatory species if a supply of game is to be maintained

A case in point was the large mortality of adult pheasants taken by great horned owls during less than a year's time on 6,000 acres of pheasant range in central Massachusetts. Here 40 pheasants were taken by not more

than three pairs of horned owls (55 *Pheasants*). For the same year the hunters' share was 171 male birds. No other predator took anywhere near the proportion claimed by the horned owl. The question that will always arise under similar circumstances is that if the 40 birds had not been taken by the owls, would other predator or destructive factors have claimed them?

A discussion of a few of the difficult situations that arise in relation to predation may help to clarify the situation for those who have viewed it with a narrow perspective and only in relation to their own interests.

Many forms of life are predaceous. Warblers, thrushes, and chimney swifts help to clear the air of insects. Small owls eat mice, rats, and small birds. Snakes eat frogs and rodents. Wolves eat mice, squirrels, rabbits, and deer. It is thus necessary to define a situation in terms of the specific items before any conclusion can be reached as to the relationships between predators and their prey. Only a few of the predaceous forms are detrimental to man's interests. Of the numerous species of hawks and owls only three or possibly four, *i.e.*, the great horned owl, the Cooper's hawk, the sharp-shinned hawk, and the goshawk are considered to be detrimental to man's interests. Many animals now classed as vermin are distinctly beneficial to man under most circumstances. Skunks, weasels, badgers, and foxes are heavy feeders on mice, ground squirrels, and turtles' eggs.

Some of the carnivores such as the weasel, skunk, mink, fox, and otter are valuable fur bearers and contribute to the livelihood of one group of human beings; others such as the red fox and raccoon are valuable both for fur and as game animals.

One of the credit values often assigned to predators is that of weeding out the unfit in wildlife populations and keeping game alert. Smith (19) records two instances of predator sanitation, in which a red-shouldered hawk killed a weakling released crow and a northern shrike killed a 7-year-old chickadee. Both of these cases are reported by one individual and occurred in a limited area. No doubt careful observations would yield many similar cases. Gabrielson (*42 g.r.*) indicates this as a possible, though poorly authenticated, value of predators.

Any carnivorous creature may get into an unnatural situation and develop bad habits or do excessive damage. For example, a weasel may get into a chicken house and develop the habit of killing chickens. Likewise, a grizzly bear may discover that it is easier to kill a heifer than to dig out ground hogs. Under these conditions it is more sensible to dispose of the guilty individual than to condemn the entire species. This at least is the procedure followed by the human race in passing judgment on its own members.

The fish-eating predators are often condemned by fishermen and others

because of the supposed inroads these creatures make by removing desirable species of fish. Raccoons, mink, and otter will take fish, as will a host of winged carnivores, including the ospreys, bitterns, herons, grebes, loons, mergansers, and numerous other water birds.

Any of these predators will do excessive damage in fish-rearing stations and under these conditions must be controlled. Control may be the destruction of the offending individuals or the prevention of access to the fish pools. Concentrations of fish in pools are always an attraction to predaceous animals, and the economic loss of valuable fish is not balanced by any known advantage of removing the fish. Here the only question involved is the cost of prevention. Screening may be a cheaper method than is a constant campaign of pole trapping and shooting.

The loss of fish by fish-eating animals in the wild is another matter, however. Studies of the food habits of at least some of these fish-eating creatures show that the preponderance of their food is slow-moving, forage or "trash" fish such as "pumpkin seeds," "suckers," or other low-grade food fish. Thus, the good done by reducing competing forms may equal or excel the harm done to forms valuable to man.

Any blanket condemnation of a group of animals based on a few observations may be both fallacious and unfair as to the harm done to man's interests. Many of the conclusions drawn by the casual observer or handed down by word of mouth are not based on facts and do not reflect the true relationship of the conditions involved.

The results of studies of the food habits of both individual predators and groups of predators in relation to poultry and game birds are available in numerous publications on this subject (10, 14). Some of these data are given under the chapters on the various game and fur-bearer species. Mendall (15), in a summary of the food habits of common hawks and owls in Maine, classifies the various species as follows:

Distinctly beneficial	Usually beneficial	Neutral	Primarily detrimental
Sparrow hawk	Red-tail hawk	Marsh hawk	Goshawk
American hawk owl	Red-shouldered hawk	Snowy owl	Sharp-shinned hawk
Long-eared owl	Broad-winged hawk	Northern barred owl	Great horned owl
Richardson owl			
Saw-whet owl			

Studies of the predatory habits of many of the carnivores both avian and mammalian throughout the eastern part of the United States have not given a clear picture of the effect of predation on a prey species. In a study of the effects of predator control on ruffed grouse in New York, Edminster (5) states that predator control does not materially increase the

number of grouse available for shooting during the period of grouse abundance but may increase it materially in years of scarcity.

In the Lake states, Errington has published the results of long-time studies on predator-prey relationships of the great horned owl (9) and on the effect of mink predation on muskrat populations (7).

Of the great horned owl, Errington and his associates (9) have the following to say:

> In view of the looseness of predator-prey relationships and the patently incidental or secondary nature of common types of predation observed in the north-central region, it should not be taken for granted that the destruction of prey by predators necessarily has significant influence on population densities maintained by the prey even when losses may be heavy in proportion to numbers. We may, indeed, ask which, if any, of the prey species would have been on the whole, more abundant, had it not been for the animals killed by the horned owls or by any specific wild predator?

Regarding the loss of muskrats by mink depredations Errington (7) states in part:

> The concept that losses suffered by muskrats through depredations by mink are largely without much actual depressive influence on the muskrat population is borne out to varying degrees by the Iowa data for all seasons of the year. This does not mean that only a small proportion of the muskrat population is killed by minks, for the latter may, indeed, kill tremendous numbers of muskrats annually in local areas and be the principal medium of reduction of many top-heavy or vulnerable populations. The distinction to be made is that under most conditions favoring heavy losses of muskrats from minks, a very material proportion of the victims (or their numerical equivalents in the population) are doomed, anyway, regardless of the presence or absence of particular predatory species.

Predation varies greatly among different localities for the same kind of predator, and also the predation on prey species in different localities may be done by entirely different predatory species. These facts are borne out by the results published by Kalmbach [1] after studying depredations on waterfowl nests. In Canada during the season of 1934–1935, 31 per cent of 512 nests studied were destroyed by crows, while less than 4 per cent of 917 nests in North Dakota during 1936 and 1937 were destroyed by these birds. During the same seasons, no skunk depredations on nests were reported for Canada, but during 1936 skunk depredations in Dakota were responsible for the destruction of 30.4 per cent of the nests examined.

From a study of the stomachs of 18,000 birds McAtee (16) reached the following conclusions in relation to predation by birds:

[1] KALMBACH, E. R. 1938. A comparative study of nesting waterfowl on the Lower Souris Refuge: 1936–1937. *Trans. 3d North Amer. Wildlife Conf.* Pp. 610–623.

. . . The combined attack of birds plus all other predators still more closely approaches complete indiscriminancy. In other words, there is utilization of animals of practically every kind for food approximately in proportion to their numbers.

The effects of predation on a prey species as indicated by a variety of studies might be stated as follows: Predation is only one of the forces of nature that reduces prey populations. Loss by predators of a well-fed prey population in a suitable environment will be negligible. Predation will be heaviest on the fringes of the population that occupy the poorest part of the range. If predator numbers are not excessive, the wildlife manager will do well to look for weaknesses of the habitat rather than expending undue efforts in eliminating predators.

Predator Control in Wildlife Management. Reduction of predaceous animals is one of the means by which wildlife managers have attempted to increase different species of game. Sometimes it has been successful, but sometimes it has given results that were more detrimental than the damage caused by the predator. A case in point is the Kaibab deer range after too effective control of mountain lions. In this instance the deer herd increased to the point where the range was severely damaged. Another case, already related, is where the destruction of skunks in a duck swamp allowed the turtles to increase and thereby almost caused the elimination of the ducks.

Two methods are commonly used to control predators: paid hunters and trappers and the payment of bounties.

Paid hunters and trappers in the western part of the continent have been used successfully by the U.S. Fish and Wildlife Service in cooperation with livestock cooperative agencies. The trappers were skilled technicians and by continuous efforts were able to reduce the numbers of a particular species or a group of species to low numbers (see Chap. XVIII, *Gray Wolf*). In describing the work of predator control on western ranges Young and Goldman (*2 Gray Wolf*) state, "Approximately three decades have passed since the U.S. Fish and Wildlife Service has been engaged in predatory animal-control work (1944)."

The state of Michigan tried a system of paid hunter-wardens from 1921 to 1934 in the Upper Peninsula. During that period these hunter-wardens destroyed a total of 14,410 predators, including bobcats, coyotes, foxes, and wolves, at a total cost of $508,872.13, or approximately $35 for each animal. In 1934 the hunter-warden system was discontinued and a bounty system was again inaugurated which was in effect in 1946.

Bounty payments to reduce a particular predator have been tried with varying results in numerous localities. The usual procedure is for township treasurers to pay a fixed sum for a pelt or some part of the animal's anatomy, with the local administrative unit usually reimbursed by the state treasurer at the end of the fiscal year. Under this system Michigan

paid out $401,585 in bounties on 361 wolves, 23,165 coyotes, and 3,653 bobcats over a 10-year period from 1936 to 1946. At the end of the period the number of wolves taken was about the same as at the beginning, the bobcats were two-thirds as numerous, and the coyotes one and one-half times as abundant (4). The conclusions of the investigators are that a low bounty is a poor incentive to reduce the predatory species and a high bounty invites dishonesty and fraud.

Pennsylvania has had many years of experience in the use of bounties in an attempt to reduce predatory pressure on game species. In summarizing the success or failure of the bounty system in Pennsylvania, Gerstell (11) gives a summary of its results as follows:

> . . . The successful operation of any bounty system depends upon precisely drawn legislation which even under present-day conditions is difficult to achieve. . . . Secondly, the advantages of the system are far more than balanced by its disadvantages. Finally, though some few particular predatory problems can admittedly be solved through the payment of bounties, opportunities for such use of the system are comparatively rare.

Apparently the attitude as to the value of predator control is not the same in all sections of the country. Kartchner (12) of the Arizona Fish and Game Commission maintains that if the federal predator-control funds of Arizona could be increased to $24,500 and the control activities coordinated, the game in Arizona could be doubled.

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CHAPTER XXVII

GAME PRODUCTION AND HARVEST[1]

INTRODUCTION

Producing game is a complex problem. Regulating the game harvest is also complex, because the game is owned by the state even where produced on private land. Complicating the problem still more is the fact that in the United States we have a system where everyone, landowner or not, is permitted to hunt.

Since the settlement of North America began, it has been the custom of men to hunt and trap on *any* available land, regardless of the ownership of the hunting range or the financial status of the gun toter. Along with this tradition of free hunting there has also developed the inalienable privilege of landowners to control trespassers. In new, partially settled country there has been little use of trespass laws because of sufficient quantities of range for everyone who wished to trap or hunt. Likewise, little objection arose on the part of the landowner to hunting done by local residents. The gradual clearing of the land and the universal use of the automobile brought in more and more hunters from cities and towns. Concurrent with the influx of urban hunters into rural areas there occurred more abuses of the trespass privilege in the form of broken fences, trampled crops, and sometimes injured livestock. Where the traffic became too heavy and the abuses too flagrant, the landowner exercised the trespass law to protect himself and his property from vandalism.

In the past there has been little thought on the part of the landowner as to who owned the game or the desirability of producing more. If the farmer did have a better crop of game than his neighbors, his difficulties were increased because it brought an additional number of hunters to his property and with them the additional nuisances.

During the early history of the country the use of game and the legal aspects of its administration were also going through evolutionary changes. The first period of use was largely to provide the necessities of life. Furs were valuable for trade, and meat and hides were necessary to feed and clothe the pioneers. Later, as settlement moved westward, deer and bison meat was used in the lumber and railroad camps, and the buffalo robe became a standard article of household use as protection against the biting

[1] The word "game" used in this section does not include fish.

winter winds. As urban centers and transportation developed, the commercial hunter sent huge amounts of game to the cities for human consumption. Feathers for decorative purposes became an important item of trade during the period of 1800–1900.

As some of the forms of wildlife became scarce, a consciousness of their values began to be felt. With this consciousness came the development of both state and federal laws and conservation administrative bodies. Laws to limit abuses of the taking of game began to appear in the form of restricted hunting and fishing seasons; limitations on the use of hunting dogs, maximum caliber of guns, number of pieces of game allowed; and various other means of protecting wildlife. It was in the latter part of this period that some thought of production or game management began to appear.

Although both game and fur bearers are the property of all the people, the economic status of game and the laws regulating it differ from that of fur bearers. In fact there are three categories of animals in relation to their legal status: (1) Resident game is administered by the state and cannot be legally bought or sold. (2) Migratory wildlife, both game and nongame species, are wards of the Federal government. (3) Fur bearers are under the administration of the state but can be bought and sold under certain legal restrictions. Some species of animals, as the raccoon, may be considered a game animal in one state and a fur bearer in another. Wildlife on federally owned land is under state regulation, but the game on Indian lands belongs to the Indians and is not subject to state laws.

Both the state and Federal governments levy taxes in the regulation of wildlife. State fishing, hunting, and trapping licenses vary in cost, and the tax is levied for different purposes. Some states have separate licenses for fishing and hunting. Different classes of game may have separate licenses, small game being under one license and big game under a separate one. Some states have a blanket license for taking of all wildlife. Usually trapping licenses are separate from hunting licenses.

Federal taxes are levied on hunting and fishing equipment such as guns, ammunition, and fishing tackle, and a license stamp is required for the taking of the migratory birds. In general, license fees serve the dual purpose of bringing revenue to operate state and federal administrative machinery and of restricting the use of the wildlife resource. License fees are in no way considered as a direct purchase of wildlife but only give the license holder the privilege of legally seeking it. In general, the landowner may take wild animals on his own land without a license but must follow both state and federal laws as to seasons and bag limits. However, he is legally allowed to protect his property from damage by wildlife at any time of year but may be required to report any animals shot or trapped.

DIFFICULTIES OF INCREASING WILDLIFE PRODUCTION

While there are many technical difficulties to overcome in any effort to increase game, the greatest obstacle to wildlife production is the lack of an economic motive. There are good possibilities for increasing wildlife in this country, but with a few excpetions management has not attained a high plane of accomplishment. In this connection it is logical to believe that *high production by management will be accomplished only if carried out by the owner or custodian of the land and then only where there is an economic incentive for doing it.* The following discussion will cite examples where wildlife management has been attempted and describe the process as well as the degree of success.

Miller and Powell (9) estimate that 80 per cent of the game taken during recent years has been from agricultural lands and that furthermore 90 per cent of the hunting has been on this class of land. Of the fur bearers, 40 per cent are produced on agricultural land. Most of the remaining 60 per cent taken on nonagricultural lands are produced on wet lands. These same investigators indicate that the yield of game for the country as a whole is light, being less than one piece of game on the average to a hunter, and that the production of one unit requires 6 acres of land even on the best wildlife ranges. This low production rate indicates that even on rich agricultural lands, like the corn belt, game will always be a low-income crop. Such a pessimistic picture of average conditions should not blind one to the fact that tremendous numbers of game and fur animals are harvested each year. Furthermore, to the individual the value of game, fish, and fur is not alone in its intrinsic value but rather in the value of the recreation it is able to support.

Different systems of production as well as ways to control hunting have been developed in different parts of the United States. In general, the Southeast and Southwest have made marked progress in increasing the production of quail and wild turkey, while in the corn belt efforts at management have been largely devoted to keeping the take of game within bounds and preventing abuses by nonresident hunters of farm property.

GAME MANAGEMENT ON PRIVATELY OWNED LANDS

The most successful examples of management on private holdings have taken place in the Southeast on plantations operated for production of quail and wild turkey as well as for forest production. Wahlenberg (*96 g.r.*) states that there are a million acres of longleaf and slash pine lands in South Carolina, Georgia, and Florida that are owned and managed for game production. Over a long period of time and with the coordinated help of agricultural, forestry, and game technicians, a satisfactory program

of integrated practices has been worked out for the production of both agricultural and wildlife crops on these lands. Costs of production under this type of management are relatively high; but since most of the costs are borne by wealthy owners or clubs that lease the lands, cost is not a dominating factor. Management activities, including census enumeration, environmental improvements, predator control, patrol work, and hunting, are conducted under the direction of the owner or lessee and usually by the resident on the land. Game production has improved greatly under this system.

Game management on ranches in the Southwest is similar, but the management is less intense and some of the patrolling is done by the state. Under ranch conditions the privilege of hunting is sold on a day or seasonal basis and the game animals are considered much as are the livestock on the same range. The value of a wild turkey is considered as about the same as a sheep, and a deer the same as a steer. On the average the kill is a deer for 200 acres and a wild turkey for 130 acres. The cost of hunting privileges varies from $2 to $4 per day (9).

Club-managed Lands. Land belonging to game clubs may vary from a small area sufficiently large for a clubhouse to extensive holdings either owned or leased on which game animals are produced for recreational use. Wildfowl clubs are common because waterfowl does not have to be produced locally. Usually the club lands either are submarginal for agricultural crops or consist of marshes and open water. Fishing clubs may own or lease extensive areas of land and water or mileage rights along the borders of a desirable trout or salmon stream. Usually the cost to the club members is high, and very little effort is made to improve the crop. Some clubs, however, have tried to increase the quantity of game. Predator control, timber management, and environmental improvements of various kinds have been attempted by various clubs, but in general the management practices have been superficial and not carried out through a long period of time. With the advances in game technology, better management of the game land will no doubt be accomplished, especially on lands owned by clubs that are sound financially and organized on a long-time basis.

Farm and Farmer-sportsman Cooperatives. The primary difference between the *farmer cooperative* and the *farmer-sportsman* cooperative is that the former has only farmer members whereas the latter has both farmer and nonfarmer members. Both types may participate in environmental improvement work and control of trespass, but reports indicate that control of hunting is generally the dominant activity (5, 6).

In the farmer cooperatives the unit of land is usually small. Such cooperatives are more likely to survive if they are a natural social unit such as a school district or a group of farmers belonging to the same

church. Usually, the prime incentive is to prevent abuse of the hunting privilege by hunters from near-by cities. Where farmers and sportsmen organize together, hunting is restricted to the members and their families, but many cooperatives do not restrict the hunting to any particular class. More generally charges are not made for the privilege of hunting, but restrictions may be made as to the number of people who can hunt the area during any one day. Other restrictions may require the hunter to park his car in a farmer's yard rather than along the road. A hunting tag and showing of the "take" of game at the end of the hunting day may also be required. The state may patrol the area controlled by a farmer cooperative in much the same way as it does other hunting territory, and in addition the club may hire special game patrolmen to assist the regular enforcement officers. Where charges are made for the hunting privilege, such revenue may be used to help defray the cost of posting the property, to pay for the special patrol officers hired during the hunting season, printing of posters, and other expenses. Financial returns from hunting also may be allotted to help support the local church, or part or all revenue may be returned to the landowners on a prorated or acreage basis.

One of the first successful cooperatives of this kind was organized in Williamston Township, Ingham County, Michigan, in 1936. The Williamston plan includes operations to increase the game crop by environmental improvements for all small-game species as well as to control trespass and excessive harvesting of game. Many of the organizations in Ohio, Wisconsin, New York, and Pennsylvania are in naturally excellent farm-game territory. These usually do not include game management activities other than control of the number of hunters. In connection with the development of such cooperatives, the Game Commission of Pennsylvania has been very successful in keeping such lands open to public hunting by closing areas around buildings for refuge use, by the purchase of grain from farmers for food for wildlife, and by a general educational program among both hunters and landowners as to the benefits of sound conservation activities.

One of the handicaps to game management on private lands in the Northern states, particularly where the pheasant is the dominant game animal, is the relatively short hunting season during which advantage can be taken of the increased game crop. Several states have overcome this handicap by allowing a longer hunting season on lands under satisfactory management. This legal provision is usually called a "game preserve law." In Wisconsin, a shooting preserve law allows the shooting of 75 per cent of the number of pheasants that are released on the preserve during any one season and has added 60 days to the regular season. On a shooting preserve in Wisconsin hens as well as cocks are allowed to be shot legally. The Riley Game Cooperative in Wisconsin described by Leopold (8) has

been in operation since 1931 and has increased the take of pheasants from zero to a total of 335 over a period of 8 years. This increase was accomplished mainly by the education of club members in relation to game conservation and the improvement of food and cover conditions in the form of fenced "remises" on cover areas.

Hill (6) gives the mortality of game club organizations in Michigan for 1937 as more than 35 per cent of the clubs organized the previous year. The reasons given as to the cause of the discontinuation of such clubs are as follows: lack of understanding on the part of its members as to the purposes of the club, lack of local leadership, discord among the members, and the presence of land owned by nonmembers intermingled with club land.

GAME MANAGEMENT ON STATE AND FEDERAL LANDS

Only a small part of the game lands of the nation can be owned or controlled by public agencies, and a relatively small number of hunters and fishermen can be accommodated on these publicly owned holdings. It is likewise very expensive to manage fish and game by public employees except as a demonstration for private owners to follow. Some states, however, have purchased lands in strategic localities where hunting and fishing pressure is heavy and have a system of state holdings in the form of state forests, parks, and public hunting grounds, which, though small by comparison, help to relieve the hunting and fishing pressure on private lands. Pennsylvania has made notable progress in acquiring public hunting grounds and is carrying on land management procedures to increase the game crop on such lands. Environmental improvements in the form of food patch and cover plantings on agricultural lands and improvement cuttings in forested areas are all designed to give the people of the state better hunting. Michigan has developed a series of experiment stations where both research and game management are carried on as a demonstration for use on private lands.

Game management practices were conducted on both state and federal lands during the era of the Civil Conservation Corps from 1933 to 1939. Stream and lake improvements, pond developments, food plantings, woods operations, and erosion control were carried to a high state of development on much of the 200 million acres of federal and state-owned lands, with marked benefits to hunters, fishermen, and the land itself.

The U.S. Forest Service has long carried on a limited form of game management in the National Forests. This program was accelerated when additional man power became available during the lush days of the federal spending programs.

The Soil Conservation Service through the local soil conservation districts has a program that will benefit wildlife as part of the soil- and water-

conserving program. Limiting grazing on steep slopes, contour farming, and revegetation of land too rough or wet for conventional agriculture are all procedures that promise to benefit wildlife. Of particular benefit to wildlife is the provision in the program of the Soil Conservation Service that encourages soil-saving operations on private as well as public lands. Only one item of this general program, the drainage of wet lands, appears to have an adverse effect on wildlife production. This phase of soil conservation if carried to extremes may largely nullify many of the benefits of the remainder of the program.

COMMENTS

The forces of destruction of wildlife and wildlife habitats have long overbalanced the forces of production. The demands for food, clothing, and shelter of a growing nation have destroyed much game habitat during the past 150 years. The era of small fields has passed to a new era of clean fence rows, large fields, and a minimum of cover. The present era of machinery farming has increased the hazards and decreased the amount of both game and its range. One factor on the credit side of the ledger is the better understanding by many of the present generation of the need for sound conservation practices and the appreciation of the value of wildlife as a national asset. This understanding has resulted from the constant and earnest efforts on the part of many well-organized groups of conservation-minded citizens. Just when the constructive forces will be sufficient to result in an aggressive and constructive program of game production remains to be seen. It is hoped the picture will change before irreparable damage is done to both wildlife and the wildlife habitat.

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CHAPTER XXVIII

REFUGES

The practice of closing land to hunting, fishing, or trapping for the purpose of allowing animal populations to increase and spread has been in use in England and other countries for unknown centuries and in the United States for about fifty years. Although refuges have not proved to be a panacea for all the ills of wildlife, they are nevertheless a useful tool for the management of many species.

DEFINITIONS

Numerous special terms are used in relation to land used for the protection of wild animals. It is necessary therefore to define each of these specific terms before considering other conditions in relation to the refuge idea.

A *wildlife refuge*, according to Leopold (*66 g.r.*), is an area closed to hunting in order that its excess population may flow out and restock surrounding areas. The reference text "Forest Terminology" (*54 g.r.*) varies this definition somewhat and defines a refuge as "an area designated for the protection of game animals, birds, and fish, within which hunting and fishing either is prohibited or is strictly controlled."

A *wildlife sanctuary* is defined by "Forest Terminology" (*54 g.r.*) as an area upon which hunting, fishing, and collecting are forbidden. Perhaps a sanctuary might be further defined as an area on which *all disturbances* are limited, particularly those of man-made origin.

Other types of land closed to public use but fitting the definition of a refuge in part are *reservations* or land on which animals are present, but with no particular reference as to their use or relationship to the surrounding area; a *preserve* or *hunting preserve*, which is land managed primarily for shooting, usually private shooting; a *park*, which is land attractive to the public because of unusual features of the landscape including its animal inhabitants; and numerous other land areas, such as *wilderness areas* and *roadless areas*, that are closed to hunting but are not primarily set aside for animal production yet serve the purpose of protecting animal populations.

The definition of a refuge has certain limitations and perhaps may need restating as the process of refuge management is better understood. For example, a refuge may serve the same purpose for nongame as for game species; again, it may develop a resident population of game that

can be trapped and liberated elsewhere. Refuges also may hold migratory species longer in a given locality, thus providing better shooting locally, or it may preserve rare and valuable species that would otherwise be subject to shooting or trapping.

HISTORY

The history of wildlife-refuge development in the United States is adequately described by Gabrielson (7), so it will be treated only briefly here. One of the first wildlife refuges in this country was established in 1870 in California; Indiana was next, establishing a refuge in 1903; Pennsylvania in 1905; Alabama in 1907; Massachusetts in 1908; Idaho in 1909; and Louisiana in 1911.

The first federal wildlife refuge was established in 1903 on Pelican Island in the Indian River on the east coast of Florida by the executive order of President Theodore Roosevelt. The first federal waterfowl-nesting refuges were established at Mahleur and Lower Klamath lakes, California, in 1908. Since the dates of the establishment of these early refuges much federal, state, and private land has been set aside for refuges.

CLASSIFICATION OF REFUGES

Refuges and sanctuaries (*not used synonymously*) can be classified in numerous ways: (1) the time they are operative, (2) ownership of land, (3) species for which they are established, (4) general or special purposes, or (5) whether they are managed or unmanaged.

1. *Time.* Ordinarily, refuges that are established for short periods of time are not satisfactory. Too frequently state laws allow a private owner to establish his land under a refuge status or take it out of this category at will. Under these conditions, a refuge may become a trap to lure game to a particular area to be slaughtered during an open season for the benefit of the landowner.

2. *Ownership.* Refuges or sanctuaries may be established on private, semiprivate, state, or federal land. Many refuges on privately owned lands are operating successfully in the United States and Canada. Each state has its own laws that make it possible for private owners to close their lands to hunting or fishing or both. Some state laws also provide special legal protection to wildlife on private lands (11). Refuges of a semiprivate nature are owned and operated by agencies such as the National Audubon Society that maintain 36 sanctuaries in 10 states (7). Refuges on state lands are found in almost every state of the union. Much land not designated under a wildlife-refuge status serves as a refuge because of laws that prevent the use of firearms within their limits (7). Rhode Island, the smallest state in the Union, has 47 of these areas totaling nearly 8,000 acres (7).

3. *Species refuges.* Refuges or sanctuaries are usually established for the protection of some one particular species or possibly several species with similar environmental requirements. In order to function properly, a refuge should contain suitable range for year-around occupancy so that breeding stock can find suitable conditions at all times *within the refuge borders.* This requirement precludes any consideration of a variety of species, although it is possible that refuges established for one species may serve a number of other species more or less efficiently. The exception to the rule of refuges containing year-around environments will be found in waterfowl refuges, which may serve a seasonal need as a breeding refuge, a flyway or a resting refuge, or a wintering refuge.

Gabrielson (7) has classified refuges into four categories as follows: (*a*) special-purpose refuges for nongame birds, (*b*) big-game refuges, (*c*) migratory waterfowl refuges, and (*d*) general wildlife refuges.

4. *General- or special-purpose refuges.* Refuges are frequently established for a game species to ensure that hunting is good in the surrounding territory, but they may also be established to hold game close to areas where the hunting pressure is heaviest. This may be particularly true with migratory species such as waterfowl. Refuges may serve the purpose of retaining a seed stock to replant surrounding "burned-out" hunting territory or to preserve a species in danger of extinction. Special uses may include the production of game to be trapped and transported to outside areas or for experimental or scientific study of either the animal or the habitat. Refuges for fish may be classified as a special refuge, although such refuges have been used for a long period of time. Closing of cold-feeder streams adjacent to trout lakes and the closing of bass-spawning areas are special applications of the refuge idea that have worked successfully with game fish. Ponds and lakes may be closed to ice fishing for several seasons to allow a fish populaton to build up where heavy fishing pressure may deplete the breeding stock in such waters.

The closing of feeder streams in larger river systems, which are known to be spawning streams for trout, has been tried with varying results. Brook trout may continue to live in waters in which they are spawned and so never get beyond the "closed" area.

5. *Unmanaged or managed refuges.* Many areas of land carrying local species of animals have been established as wildlife refuges with no thought of management in mind. Such refuges gradually reach a balance in relation to plants and animals and go through the various stages of succession to a climax state. A refuge of this kind would be less likely to serve a truly refuge purpose than one managed to produce and retain a maximum number of a given species of animals. For example, a refuge for deer would need silvicultural treatment of the cover in order to keep wintering swamps in condition and to supply a maximum of food. Treatment of

vegetation on the rest of the refuge would also be desirable in order to keep abundant supplies of food for the remainder of the year as well as cover suitable for resting, feeding, breeding, hiding, sleeping, and escape from insects and other enemies. Management for different species would vary but would, if intelligently executed, be likely to produce more game than areas where no treatment of the vegetation was administered.

REFUGE SPECIFICATIONS

A refuge should be large enough for all seasonal activities of the animal for which it is established. Birds and mammals vary greatly in this respect, so a careful analysis of any area should be made before the refuge site is selected. In case the refuge is set up for several species, all the needs of the various animals should be considered.

The value of the land is also an important consideration in determining the size of a refuge. Valuable farm lands may not be available and would probably cost more than the returns would justify. Likewise it may be possible to establish refuges on farming territory by other means than by state or federal ownership.

Table 71 gives a summary of the approximate daily and seasonal cruising distances for some of the common game animals.

TABLE 71. APPROXIMATE DAILY AND SEASONAL CRUISING DISTANCES FOR A SELECTED GROUP OF GAME ANIMALS AND SUGGESTED SIZE AND DISTANCE PATTERN FOR REFUGES FOR EACH GROUP

Animal	Cruising radius, miles		Area in refuge *	Distance apart, miles
	Day	Season		
Waterfowl	50	(†)	200*A* and up	50–100
Moose	5		25*MA*–75*MA*	
Whitetail deer	2	6–15	2*MA*–8*MA*	12–25
Wild turkey	1	4	2*MA*–15*MA*	12–25
Pheasant	⅛–½	½–3	½*A*–500*A*	½–5
Quail	⅛–¼	½–3	½*A*–10*A*	½–2
Cottontail	⅛–¼	1	½*A*–10*A*	½–2

* $M = 1{,}000$; A = acres.

† Different for different species, little information available.

MANAGEMENT OF REFUGES

Management of refuges has been summarized by the U.S. Forest Service (2) and Gabrielson (7) into a number of operations, including the initial selection of the area; the establishment and marking of its boundaries; the patrol and control of human activities, fire, and predators; the manipulation of water levels; the control of vegetation; and the regulation

of animals that may interfere with the species for which the refuge is established. Other factors that require attention in connection with refuges are a careful analysis of the purpose of the refuge and provisions for the removal of the refuge status after its usefulness has passed.

Refuges for waterfowl are largely under federal control, although many states also have excellent waterfowl refuges. For waterfowl there should be available clean water with a variety of depths depending on the species for which the refuge is intended. Border areas should be sufficient in size to provide nesting and breeding cover properly protected from grazing farm animals and from human activities. Breeding refuges ought to be at least half water, but with both land and water areas broken up into many small units so as to provide a maximum of "edge." Water levels should be stable from May to August to insure against the loss of duck nests and ducklings (7).

Flyway refuges should provide not only a good proportion of water but also a maximum of food and grits for visiting waterfowl. Abundant food not only provides the passing migrants with needed nourishment but likewise attracts birds to a haven of safety. With respect to food requirements flyway refuges are much like a transient hotel for human beings. Vast numbers of ducks will visit such refuges if the food is ample and protection from gunners is provided. Gabrielson (7) suggests manipulation of water level so that lands growing wild millet, smartweeds, and nut grass can be maintained in a semiwet condition during the summer period and covered with water during the fall to make food available for the migrating waterfowl.

Wintering refuges are located along the coasts of the Atlantic and Gulf states as well as inland along the Mississippi River basin of the Southern states. These refuges are concentration points for waterfowl and need a large quantity of food and sufficient water and grit for the great numbers of birds using them.

Refuges for waterfowl should be selected with particular care. Nesting cover, food, and areas suitable for resting and molting and special needs should all be provided for within such special areas. In this connection, the need for additional local research is indicated by the differences in the food habits of inland black ducks versus coastal black ducks north of Cape Cod. Inland, the food is largely vegetable, while on the eastern coast it is largely animal.[1] Such differences should be carefully considered when the refuge development is planned.

Laws for the establishment of refuges may be of either state or federal origin. State laws vary considerably in details as to ownership of land, means of establishing refuges, time during which the refuge status exists,

[1] Personal information on food habits of black ducks along the Massachusetts coast supplied by Joseph A. Hagar, Marshfield, Mass.

and causes for discontinuing them. The most stable refuge status is found on land owned by states or by the Federal government.

Gabrielson (7) points out that establishment of the boundary by adequate marking or posting is the first requisite of a good refuge. Where possible, refuge boundaries should follow well-marked boundary lines. Where a boundary passes through wooded territory or the localities where the refuge borders lands used for hunting or other activities, the border should be brushed out and marked with a No. 9 wire and adequate signs, so that failure to recognize the boundary is impossible. Entering paths, roads, and streams should be conspicuously posted.

Patrol activities should, as far as possible, eliminate poaching on refuge areas. Patrolling is especially needed during the hunting season, as the public usually has a false idea of the density of game in refuges.

Fencing has been used on refuges where particularly valuable animals need protection or where a fence is needed to restrict animals with migratory instincts. In general, however, stockproof fencing is too expensive for any except special conditions.

Control of fire in refuges should be part of the fire-control plan for both the refuge and the surrounding area. A refuge should receive extra vigilance, as it may carry the only breeding stock available. Loss hazards are usually the most extreme during breeding and nesting season from March to September. Aside from the direct loss of animals from fire, the probable greater loss is the indirect effect a fire has on changing the environment. These losses include damage to the soil, removal of the humus layer, and destruction of the protective plant cover.

Uncontrolled fire is detrimental, but controlled burning may be a useful tool. Gabrielson (7) points out the value of burning on the Louisiana marshes late in the fall to induce sprout growth as winter food for geese. Impounding of water may reduce the fire danger by flooding hazardous areas of dry vegetation and creating water barriers to prevent the spread of fire or to be used in putting it out. An additional value from the flooding of low areas may be provided in the creation of additional edges between the water and land.

Environmental control of the vegetation furnishes a means by which a refuge can be kept in its most productive condition. This may include logging or cutting of fire wood, planting, burning, brush removal, and many other cultural activities. Forestry activities are covered quite completely in Chap. VII, Wildlife Management in the Forest, so need not be repeated here.

Limited grazing by domestic animals may be effective in holding back natural succession of woody plants on refuge lands or in preventing the development of a dense herbaceous cover.

Control of both wildlife and human populations on a refuge is im-

portant. There should be a minimum of human activities on a refuge during the breeding and nesting season of the species to be favored. Education of the local people combined with tact and firmness will usually solve this problem. Control of animals other than the species for which the refuge was intended may require drastic action. Control of fur-bearing predators should be carried on through harvesting of a fur crop. Mink, muskrats, skunks, coyotes, bobcats, foxes, and raccoons may be included, but these are not always predatory and so may need little special attention. Where earth dams are necessary to hold back the water, the muskrat may be detrimental because of its burrowing habits. If maintained in excessive numbers muskrats may destroy too much vegetation. A proper number of muskrats seems desirable on a waterfowl refuge to maintain open spaces in marsh vegetation.

The management of refuges as escape islands for farm game in intensively hunted areas and as a source of surplus game for restocking public hunting grounds is not well understood but gives promise of a definite value not always fully appreciated. The Ohio State Conservation Department has trapped 1,000 pheasants annually from a 520-acre privately owned refuge in Wood County for a period of several years (10). In Pennsylvania during the 1942–1943 season, 33,000 game animals were trapped on areas closed to hunting and released on hunting territory.

Many areas of land lend themselves naturally to use as wildlife sanctuaries. City park and golf club grounds are usually protected against shooting, but each is limited in its attractiveness to birds and mammals by a lack of necessary living conditions. For example, both park commissions and golf club associations are likely to clean up dead or decadent trees, which may be the only nesting sites for such birds as tree swallows, wood ducks, chickadees, and flickers. Water impoundments, bird baths, establishment of both food and cover, installation of nesting boxes, and numerous other activities will tend to enrich the fauna of these sanctuary areas. The subject of improving the golf course for birds is well illustrated by an excellent bulletin published by the National Association of Audubon Societies, New York (8).

There is a need for permanent sanctuaries for a few of the rare mammals that Gabrielson (7) has indicated have not yet been provided for. These include the grizzly bear, moose, woodland caribou, mountain goat, marten, fisher, wolverine, timber wolf, and cougar. Certainly a country as vast and wealthy as the United States can afford to perpetuate its native fauna. All refuges for this purpose should be large and, if possible, located in range already occupied by the species.

For example, in setting up refuges for moose, provision should be made that when the population has exceeded the carrying capacity of the range,

enough of the animals can be removed to ensure the protection of both the moose herd and its food supply.

A refuge for mountain goats would of necessity be located in the high Rockies. Any one of several areas in Montana might serve as a refuge for this species and possibly also for the wolverine, marten, and fisher. Sanctuaries for the marten and fisher also should be provided in the East, in some of the less accessible parts of the Adirondacks or in Maine or New Hampshire.

A plan proposed indicates the need for a natural grassland reserve of adequate size and sufficiently unspoiled by man so that a place is available to study the natural vegetation and also to act as a suitable laboratory for the study of rodent and insect control by biological rather than artificial means. After careful study, committees from the National Research Council and the Ecological Society of America selected western Nebraska, North and South Dakota, eastern Montana, Wyoming, and Colorado as providing the best localities now available. The size of the study area suggested is a million acres, and the request specified that the land, which is mainly used for grazing, should be set aside as a national monument.

The suggestion of a combined grassland sanctuary and experiment station has great merit in that it involves not only the preservation of natural fauna and flora but also an experimental area for the study of the Western range animals including prairie dogs, ground squirrels, coyotes, mice, foxes, badgers, and many insect pests (9).

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CHAPTER XXIX

WINTER FEEDING

INTRODUCTION

Winter feeding, as related to wildlife management, provides wild birds and mammals with supplemental food during the winter months (6).

The practice is of ancient origin, for indeed the earliest available record shows clearly that winter feeding was well organized more than six centuries ago in the Mongol Empire. Marco Polo records this fact in a report of his travels across Asia, where, at Cathay, he found on Kublai Khan's hunting preserves large food patches and a well-developed system of winter feeding and cover control (*66 g.r.*).

At present, this activity is a popular phase of game conservation programs throughout the northern United States and southern provinces of Canada. Its popularity and extensive practice seem to arise principally from an instinctive human urge to provide birds and mammals with food during severe cold weather and a common, although erroneous, belief that game production can be increased by winter feeding (6).

PROS AND CONS OF WINTER FEEDING

A thorough investigation of the practice of winter feeding by Gerstell (6) in Pennsylvania indicates the following advantages and disadvantages:

Advantages. 1. Active cooperation in general conservation programs may be secured through public interest in winter feeding programs; *this is most important.*

2. Birds or mammals in a given locality may, at times, be held temporarily for a specific purpose such as "gunning" or protection by providing them with extra food in winter.

3. Small numbers of birds and mammals that otherwise might perish are sometimes carried through the winter by such feeding.

Disadvantages. 1. Winter feeding will not prevent wildlife decimation in areas subject to unusual winter severity despite extensive winter-feeding activities by man.

2. Inefficiency is characteristic of the work, as large portions of the distributed food are oftentimes utilized by animals less desirable than the species for which the food is intended.

3. It is nearly impossible to conduct large-scale feeding operations during severe winter weather and impractical in view of the small percentage of the total population benefited.

4. Certain dangers are involved in winter feeding: These are attraction of predators to the feeding site, disease as a result of excessive population concentrations, fatal digestive disorders resulting from gorging on artificial foods, and dependence upon man for the food supply.

5. It tends to reduce the wildness and hence the sporting value of certain species.

On the basis of these considerations and the results of numerous fasting experiments with birds and mammals under simulated winter conditions, Gerstell concluded that winter feeding is unnecessary.

With these facts and this conclusion in mind, it would seem to be in order to review briefly the relationship of winter weather to wildlife.

RELATIONSHIP OF WINTER WEATHER TO WILDLIFE

Lethal Effects. Obviously, the major limitation imposed by winter weather upon any species is mortality. Throughout the literature there are numerous references to winter mortality among wild bird and mammal populations in widely scattered localities of the northern United States (*4 g.r.*, *40 g.r.*, *41 g.r.*, *65 g.r.*, *66 g.r.*, 6).[1] In general, birds appear to be subject to greater winter losses than mammals (6). The apparent greater winter losses among birds would seem to indicate that they are not so well adapted for cold weather as the more commonly observed mammals. Forbush [2] pointed out that snowstorms sometimes drive far south of their normal latitudes and create intolerable conditions for wintering and migrating birds (*4 g.r.*).

The periodic lethal effect of unusual winter weather seems to demark the northern limits of the range of some species, particularly that of the bobwhite quail (*65 g.r.*, *66 g.r.*, *14 Bobwhite Quail*) and the fox squirrel (*4 g.r.*, *2 Tree Squirrels*).

Winter losses among mammals are most apparent among the big game herbivores of the Northern states, where localization, or "yarding," of the herds of deer and moose following deep snowfalls oftentimes results in overbrowsing of the locality. Malnutrition and subsequent death annually remove thousands of these animals, particularly deer.

Nonlethal Effects. There also are nonlethal effects that influence wildlife. For instance, certain Michigan studies show that the modified

[1] TRAUTMAN, MILTON B., WILLIAM E. BILLS, and EDWARD L. WICKLIFF. 1939. Winter losses from starvation and exposure of waterfowl and upland game birds in Ohio and other northern states. *Wilson Bul.* **51**(2):86–104.

[2] FORBUSH, EDWARD HOWE. 1904. The destruction of birds by the elements in 1903–04, Massachusetts State Board of Agriculture, Boston.

behavior of cottontail rabbits (*2 Cottontail Rabbit*), skunks [1] (*2 Cottontail Rabbit*), and raccoons (15) may condition their harvest during early winter. The phenomenon of hibernation of woodchucks and bears is familiar to nearly all persons; it is doubtful that winter crises impose many limitations upon these creatures.

It is commonly stated or implied that animal fecundity, or prolificness, is impaired by wintertime food shortages. Information gathered by Gerstell (6), however, indicates that most species of birds and mammals can undergo appreciable loss of body weight during the winter months without suffering reduced reproductive powers.

Neither does a lack of grit and drinking water at this season appear detrimental to birds. A number of investigators (6, 11, *8 Bobwhite Quail*) have demonstrated that certain gallinaceous birds and waterfowl are able to retain grits already in the gizzard for several weeks until new supplies become available. Water usually is available in open pools or streams or possibly contained in frozen vegetation that is succulent. When these sources of moisture are lacking, however, snow may be available and is readily taken by both birds and mammals.

James S. Bishop asserts that occasionally in late fall there may be a few weeks of cold weather without snow, during which it is common for the deer in Connecticut to change their bedding grounds to locations where open water is available.

Rabbits and hares may be benefited by snowfalls that elevate them to new browse supplies previously out of reach. However, it is also conceivable that extremely deep snows might cover many low sprouts and blackberry canes as well as former available shelters. Under such adverse conditions these mammals may suffer severely from exposure to sleet and excessively low air temperatures.

Most unique among our native game species that are active throughout the winter are the ruffed and pinnated grouse. The bud-eating proclivities, feathered feet, and other peculiarities of ruffed grouse make them practically immune to the usual winter hardships. Pinnated grouse, or prairie chickens, also are quite winterproof; for although they roost and tunnel under snow, there are no reports of their imprisonment therein (*66 g.r.*).

The relative effects of different degrees of cold upon certain economically important wild birds and mammals without food have been demonstrated by Gerstell (6). His findings show, on the average, that the survival period of animals undergoing complete fasts was approximately 10 per cent longer at 40 than at 0°F. The investigator points out that additional evidence is at hand to show that fluctuating temperatures, particularly those going below the freezing point, produce greater ill effects in some

[1] Allen, Durward L. 1939. Winter habits of Michigan skunks. *Jour. Wildlife Mangt.* **3**(3):212–228.

species, notably the white-tailed deer, than relatively low but constant environmental temperatures. Further experimentation showed that at temperatures of 0°F. the average survival period of birds and mammals undergoing complete fasts was reduced almost 25 per cent by subjecting the animals to constant air movement of only 5.8 miles per hour, as compared to those animals protected from the wind at these same temperatures. The importance of suitable winter cover is evident.

Malnutrition may cause a heavy toll of life among dense concentrations of deer, elk, and moose populations. Death occurs because with the deterioration of good-quality browse, the animals take foods of lower nutritional value that oftentimes do not sustain them. Classic evidence of such losses is provided by the deer problems of Pennsylvania, New York, Michigan, Minnesota, Colorado, Utah, and Arizona; the annual losses among the Yellowstone elk herd; and the "die-off" of moose on Michigan's Isle Royale. It is becoming obvious that reduction of many big-game herds is needed if the deer herds and the quality of their wintering range is to be maintained or improved.

At times snow and ice may seal the nasal and oral openings of birds or imprison pheasants, ruffed grouse, Hungarian partridges, rabbits, and even entire coveys of quail, thus reducing healthy well-fed game populations when suitable cover is not available (*4 g.r.*, 14; *28 Ruffed Grouse; 30 Pheasants; 66 g.r.*).

Perhaps of minor importance is the killing during early winter of many species that are subnormal due to disease, injury during the hunting season, or lead poisoning as in waterfowl (*4 g.r.*).

Occasionally, instances of starvation are observed in many species, particularly in bobwhite quail, but the number of individuals usually is comparatively small when compared with the aggregate population totals of the species concerned. Gerstell (6) has observed that many of the game and fur-bearing animals can survive without food for several days even at low temperatures. Bobwhites, however, are not a hardy species; and in the northern parts of their range, winter is an extremely critical period in their lives (*14 Bobwhite Quail*).

In brief, winter is a period of increased crisis to nearly all species (hibernating animals not included) because of emergencies associated with snow, low air temperatures, and wind. Furthermore, natural foods and coverts diminish in both quantity and quality at this season, but there is little evidence that this condition is an important "bottleneck" to game production.

Despite the fact that the actual need for winter feeding is only occasional and local, large-scale programs doubtless will continue annually in most of the Northern states and southern Canadian provinces where winter severity stirs human sympathy. This, in turn, can be used ad-

vantageously to promote public interest in more intelligent wildlife-conservation efforts.

SUPPLEMENTAL FOODS AND THEIR PROVISION

If supplemental food supplies are to be provided most effectively, it will be far better to produce additional natural foods than to "feed out" artificial foods. This can be done by planting or encouraging the growth of

FIG. 29·1. Supplemental winter food for pheasants. Ear corn is being placed under feeding shelters for pheasants. (*U.S. Fish and Wildlife Service.*)

persistent food-bearing shrubs, trees, vines, legumes, and grasses on eroded or rough land unsuitable for cultivation (*5 The Farm as a Wildlife Habitat*).

By way of explanation it can be stated that the provision of artificial foods alone is usually unsuccessful in increasing the game-carrying capacity of a given area. Other animals that benefit from such activities are the ever-present winged and mammalian predators which are marvelously efficient in keeping the numbers of prey species within the carrying capacity of their winter range (*14 Bobwhite Quail*). The more automatically the food remains available and the more alternative methods that game has to secure these supplies in the event of visitations by predators the more security may be assured.

The preferred staple and emergency foods of individual species at different seasons have been given in this text whenever such information is known, and the reader is directed to the individual chapter for specific

animals when the production of natural food supplies is to be undertaken.

Incidentally, there are a number of informative publications available that deal with plants valuable as food and cover to wildlife; these include plants useful for waterfowl (*72 g.r.*), plants useful for upland game (12), plants useful for wildlife and erosion control (*93 g.r.*), and legumes useful for wildlife and erosion control (*46 g.r.*). Miscellaneous articles on this same subject will be found in *The Journal of Wildlife Management* and the *Transactions of the North American Wildlife Conferences.*

In the meantime, while the longer range project of producing natural foods is under way, it may seem desirable to provide artificial foods for certain wild birds and mammals during immediate wintertime emergencies. The term "artificial foods" as encountered in this chapter refers to those foods which cannot reproduce without cultivation, while "natural foods" includes those foods which, when established, usually reproduce their kind more or less abundantly without human assistance.

The following paragraphs will summarize the various feeding methods now in use.

Continuous Feeding Methods. In these methods constant supplies of food are artificially provided throughout the winter months, regardless of weather conditions, in food patches or at feeding stations.

The food patch is a small area of land on which grain is left uncut or placed in shock for the use of wildlife. Quarter-acre plots are sometimes recommended for the use of upland game birds, but ½- to 1-acre plots probably are better in view of the capacity of rodents, deer, or other competitors to consume available supplies. Mice alone on a southern Michigan farm removed 46 per cent of the corn from shocks placed on sod cover and 17 per cent of the corn from shocks left standing in the cornfield from January until April (10).

Food patches should be long and narrow rather than square in shape. On agricultural lands they can be planted at the same time the regular grain crops are sown or created in the fall by leaving a few rows of uncut corn or a few shocks of corn or sheaves of grain near suitable cover such as a brushy fence row, wood lot, marsh, or kettle hole. On nonagricultural lands food patches may be established in wood-lot openings having a diameter of at least twice the height of the surrounding trees or on gas and power line rights of way.

An early maturing field corn that has stout stalks is excellent for most farm-game species. At least two cultivations are necessary for satisfactory ear production, after which weeds may be allowed to grow in the patch, since they provide dense ground cover as well as additional sources of food. Where landowners object to the volunteer growth of weeds, it is recommended that buckwheat, Sudan grass, millet, barley, or prepared seed mixtures be sown broadcast just prior to the second cultivation. Such weaker

stemmed grains provide some cover and sustain the birds until the corn is needed.

It is further suggested that anyone planning to establish food plots should consult with his state game department regarding the best seed mixtures and planting methods for his particular locality. In any event, food patches should not be farther apart than the seasonal cruising radius of the species (*66 g.r.*).

Grange (7) suggests that in areas where bobwhite or Hungarian partridges are abundant, one feeding station for every 40 acres is desirable; otherwise, a station may be established near the thicket that a covey is known to use. For ring-necked pheasants and sharp-tailed grouse, one station per square mile is recommended; for prairie chickens, one station every 5 or 10 square miles; and for wild turkeys, in all the permanent winter locations they are known to frequent.

Where corn is left in shocks for wildlife, it may be necessary to open the shocks in late winter in order that ears within the shocks and emergency refuge be made available to birds. In this connection rabbits and squirrels may assist the wildlife manager. It has been observed (*14 Bobwhite Quail*) that rabbits frequently make corn available to quail after ice storms by biting through the ice glaze on the ears and that squirrels often drop quantities of corn and acorn fragments at the bases of trees, where they may be found by other animals.

Another technique of providing continuous supplies of artificial foods throughout the winter involves the construction of feeding stations and shelters of various types wherein the food is placed at more or less regular intervals. Such feeding stations may vary from natural spots of protection, such as hollow logs and overhanging rocks, to complicated structures with automatic supply bins.

Brush shelters are commonly used in connection with artificial feeding of farm game. They are formed by piling cornstalks, evergreen boughs, or other debris on branch frameworks. Shelled grains or cull apples can then be scattered under these snowproof shelters. Wire-basket feeders are suitable for turkeys and squirrels. One form of such wire feeders can easily be made with 1½-inch poultry netting which is bent into a cylindrical form and wired or hung to a tree for feeding eared corn. Another method of providing eared corn to birds and squirrels is to nail a pole to two trees about 5 to 7 feet above the ground. The ears are then placed on upright spike points protruding from the pole. If not fouled by snow these elevated stations prevent the depletion of the food by rodents.

Full construction details of feeders and shelters as well as many additional types are described in Conklin and Morton's (3) brochure.

During any winter, continuous feeding methods are superior to intermittent feeding for all species subject to wintertime shortages of natural

foods. This is particularly true of the food patch, which provides food and some shelter to farm game with little or no attention from man. Furthermore, game becomes acquainted with the location of food patches before a crisis occurs, which is not always true for feeding stations, especially those established during emergencies. There is danger, however, of the patch being depleted prematurely in fall by deer, rodents, rabbits, and nongame birds or by the game itself.

Emergency Feeding Methods. In these methods supplemental foods are artificially distributed during periods of severe weather at places where game is believed most likely to find and use it. The activities are discontinued when the crisis ends.

Leopold (*66 g.r.*) has indicated that emergency feeding is suitable only in those areas where the winter season is characterized by occasional severe storms and for animals that winter in coveys (also flocks and bands) or herds.

Under this method shelled grains or eared corn may be scattered on a hard snow crust or placed in hoppers and under shelters located within the daily cruising radius of the species. Artificial foods in the form of commercial scratch feeds may be used for such emergency winter food, since these are readily taken by most species of farm game.

The necessity for frequent replenishment of emergency feeding stations dictates their location near dwellings. Here the grains may be placed in or adjacent to a brushy fence row or corner, drainage ditch, weed patch, or other natural cover, which will provide wildlife with some protection from cold winds and predators. Most important, however, is to place the feed where game will find it.

The value of emergency feeding of big game is highly controversial among both sportsmen and wildlife investigators. Some sportsmen reason, and logically too, that a hungry deer herd can be maintained through the winter if supplemental food supplies are provided. Such a feeding program is spectacular and appeals to many persons as good conservation. But is it?

Quoting from the Region 9 "Wildlife Handbook" (U.S. Forest Service, 1940, page 30) we learn

1. It [emergency winter feeding] tends to decrease the health and vigor of the herd, because the weaker individuals are permitted to survive and reproduce. Infections of parasites and disease may become acute.

2. It concentrates deer in the feeding area; and unless rations are abundant, severe overbrowsing is apt to occur in these local areas.

3. It is expensive and at best only a small proportion of the total population can be reached. [Helicopters some day may find another practical use in this field.]

Factual fuel has been added to the fire of controversy by the results obtained in a winter-feeding study of Michigan whitetails (4), Colorado

mule deer (2), and Utah mule deer (5). The data in these reports show considerable difference in the sustaining value of artificial deer foods, although all are in accord that feeding deer is expensive and impractical.

The food most commonly used to feed big-game herbivores is a good grade of alfalfa or clover hay. In New York state a molasses-soybean concentrate packed in a tin container has proved satisfactory in feeding deer.

Natural browse supplies in swamp-type deer yards of Michigan have been artificially augmented during the winter by cuttings in or near the yarding grounds (13). Release cuttings made at the time of critical wildlife need not only make browse immediately available but also encourage the reproduction of future deer food.

Emergency feeding is distinctly an eleventh-hour effort to save a relatively small number of animals, and it requires advance preparation and the cooperation of many willing workers. For emergency feeding to be effective the feed must be purchased and stored before the emergency occurs and in sufficient quantities to provide feed for a prolonged feeding period. The superiority of self-feeding stations is evident.

Incidental Feeding Methods. In these, food supplies may be augmented by certain practices.

The pruning of fruit trees, ordinary agricultural practice, is an operation usually carried out in late winter. The prunings provide excellent food for rabbits and if distributed outside the orchard may prevent severe damage to the trees within.

Spreading or piling of manure every few days in outlying fields supplies undigested grains for birds.

Finally, forestry operations that leave the slash provide deer, rabbits, and hares with additional food supplies. Brush piles also may be used as winter retreats by certain small-game species.

Passerine birds may be provided with winter feed by hanging suet in wire cages or imbedding grain in suet in trees and shrubs around dwellings during the cold and snowy part of the winter. Grit and scratch grain may also be provided in sheltered feeding shelves but should be placed away from the ground in order to protect them from prowling cats.

In general, winter feeding has certain appeals and advantages that assure its continuance in the Northern states despite the fact that all available evidence indicates it should be considered only in the light of a minor part of a year-round program of management.

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Section V

WILDLIFE ADMINISTRATION

CHAPTER XXX

WILDLIFE ADMINISTRATION AND POLICY

STATE ADMINISTRATION

Records of the first attempts to administer game are lost in the unwritten history of primitive tribes. Taverner (23) has developed the theory that tribal taboos which were effective in preserving the game supply helped the tribes using such measures to survive and prosper. Coming down to the first written records, the Mosaic law of Moses is the first restriction on the taking of game in the sense of leaving breeding stock. Then a long forward step in wildlife development is represented by the game laws of Kublai, "The Great Khan," who lived between A.D. 1259 and 1294. He enforced closed seasons during the breeding seasons of the important birds and mammals of his empire and also provided winter food for them (*66 g.r.*).

The administration of game as we now know it stems from the legal codes of England. From the time of the Norman Conquest in 1066 until the signing of the Magna Charta in 1215, the King owned the game and distributed it as a personal prerogative. The Magna Charta provided that the King still owned the game, but only in his sovereign capacity in trust for his subjects.

When the first colonists arrived in America, they were forced to place dependence on game as a source of food. It is therefore not surprising that some of the earliest laws of the Plymouth Colony were concerned with game. As early as 1623, provision was made that hunting and fishing were to be free to all members of the colony. Based on this early concept and on the formation of our state governments, a system has grown up under which the individual state is the owner of wild game and handles its administration with one noteworthy exception—migratory game. Furthermore, the principle has been very strictly adhered to that an individual becomes owner of wild game only when he legally reduces it to possession. Game propagated in captivity by an individual belongs to him, and he can do what he wants with it until it is released. Once it is free, even though it may still be on his land, it reverts to the state.

A conflict of interests and of laws arises out of the ownership of land on which game is living. The landowner has the legal right to determine who shall trespass on his land, so that no person has the right to pursue game on the land of another without first obtaining the owner's permission. This has led to very real support from sportsmen for land owned by state and federal governments on which hunting and fishing are open to the public. Even though lands are owned by the Federal government, the state still controls the taking of game thereon unless this right has been given up at the time federal title was acquired (*66 g.r.*, 22).

The state responsibility for the administration of game has led to widely varying laws and organizations. During the earliest days of the New England colonies venison for food and deerskins for clothing were purchased from the Indians. Some of the laws of colonial time were directed toward the regulation of this trade. However, in 1646, the town of Portsmouth, R.I., ordered "that there shall be noe shooting of deere from the first of May till the first of November; and if any shall shoot a deere within that time he shall forfeit five pounds; one half to him that sueth, and the other to the Treasury" (*2 Deer*).

As human populations increased and those of fish and game decreased, the states developed systems of laws and organizations to handle game-law enforcement; they also established game farms and rearing pools, public shooting areas, refuges, and study areas. The various state game and fish departments differ in their size, organization, powers, and responsibilities. Some are politically controlled, and others are so organized as to be relatively free from undesirable political pressure. Some are almost one-man institutions; others are run by a large commission. The tendency is for them to become more and more organizations of technically trained career men, carrying on a specialized form of applied biology.

Considerable study has been given to the subject of the ideal state game and fish department. Leopold (14) gives the following minimum requirements for a properly organized state game and fish department:

1. Freedom from political overturns.
2. High enough salaries to obtain and hold the ablest executives and research men.
3. Political freedom to formulate policies, regulate seasons, buy and manage land, etc.
4. Stability to follow a policy for at least a decade.
5. Close coordination among game, forestry, and agriculture in research, administration, and education.

Later (*66 g.r.*) he stated, "Experience seems to show that no particular form of organization has any inherent merit in and of itself. Merit lies only in personnel, and any particular form is good or bad only in so far as it provides a good or bad mechanism for the personnel to work with."

However, it also must be said that public attitudes or politics can undermine the best organizations having the highest type of personnel. The form of organization that seems to promise most in the way of stability and freedom from political upsets is borrowed from industry. It consists of a commission of five to nine members appointed by the governor for staggered terms of service, so that no one governor is able to appoint a majority of the members during his particular term of office. These commissioners serve without pay, but their expenses in connection with the work of the commission are paid. The commission appoints a director who is responsible for carrying out the work of the department and who in turn selects the personnel to work under him. Ideally this director should be a technically trained man with proved administrative ability; but even if not technically trained, he should be willing to use trained men to direct the technical phases of the work. In short, the commission makes the policies, and the director puts them into operation. The director's term of office and those of his regular personnel should be indefinite, to continue as long as the work is satisfactory.

Interested and organized public opinion backing state departmental fish and game work is also very necessary. Organizations of sportsmen, landowners and advisory councils, foresters, and the like can often furnish the criticism of policies, legislative backing, and general support that the commission and the department need.

Even with all these safeguards, which would seem to guarantee smooth departmental operation, departments that have worked well for long periods of time may go astray. The reelection of appointive officers or loss of members from the commission may result in "packing" it with members appointed for political reasons, a condition that usually leads to an upheaval within the department. This is where organized public interest and support can aid in righting such an unfavorable situation.

Generally speaking, sportsmen have paid far too little in license fees to carry the costs of producing and administering fish and game. For this reason no money from the sale of hunting and fishing licenses should be diverted to other than game and fish work. When needed, other public funds should help to support the cost of projects such as refuges, law enforcement, etc., since these projects provide public benefits other than fishing and hunting alone.

State game-warden organizations should come under civil-service regulations, and the individual warden should be adequately trained in wildlife management so as to be able to teach landowners and sportsmen's clubs how to produce better crops of game and fish. The wardens should consider that their job consists as much of teaching and public-relations work as of law enforcement.

State universities and colleges with their staffs of specialists in allied

fields are usually in a much better position to do wildlife research than the individual fish and game departments. Also, the state extension services are the logical means of disseminating information on wildlife management, especially as it relates to a correlation with other land uses.

Many state fish and game departments have failed to function most effectively because they had no way to keep the sportsmen informed as to what was being done or the means to get them interested in the work of the department. A suitable public-relations program includes a well-run departmental news publication combined with a good educational program of lectures, radio broadcasts, etc. Such a program can help sell the state's fish and game objectives, and, at the same time, make the sportsmen feel that they have a very real interest in the state's fish and game affairs.

FEDERAL ADMINISTRATION

Under our American government there is a division of power between the nation and states working under the Constitution. The Federal government controls foreign and interstate commerce and foreign affairs, makes treaties, administers the territories and other property of the United States, and raises money by taxation to be spent for the general national welfare. National jurisdiction over wildlife comes from a broad interpretation of these powers. Every one of the ten executive departments of the Federal government is in some way involved with the administration of wildlife.

This national jurisdiction has proved very valuable in many ways. For example, it has allowed the making of international treaties for the protection of migratory animals threatened with extinction; the passage and enforcement of legislation for the protection of migratory species within the United States; the control of wildlife on the public domain and other Federal governmentally owned lands; the raising of money by special, nation-wide taxes for use in wildlife production or protection; and the organization of various phases of production, protection, and investigation in many Federal governmental departments.

One of the oldest and best known of the Federal governmental agencies working with wildlife is the U.S. Fish and Wildlife Service, which was until recently called the U.S. Biological Survey. It had its real beginning in 1883 when the American Ornithologists' Union set up committees to study the distribution of American birds, the English sparrow, and bird migrations. The last-named committee sent questionnaires to all parts of the country, and the interest was sufficiently great that in 1885 a Federal appropriation of $5,000 was made to carry on the project. The work was placed under the U.S. Department of Agriculture within the Division of Entomology. The following year the work was continued as the Division

of Economic Ornithology and Mammalogy in the same department. Ten years later (1896) it became the Division of the Biological Survey, and in 1906 the Bureau of Biological Survey was set up as a separate independent unit within the Department of Agriculture. Its purpose as stated in the act of 1885 was "Investigation of the food habits, distribution, and migrations of North American birds and mammals in relation to agriculture, horticulture, and forestry." The early work included predator and rodent control and the continuation of the studies on bird migrations. In 1900 the Lacey Act forbade the shipment in interstate commerce of game illegally taken or shipped in violation of state export laws. It also made illegal the importation of foreign species except under a permit from the Secretary of Agriculture. Enforcement of federal regulations was delegated to the U.S. Biological Survey, and from this began the present Federal game-warden service.

Some idea as to the increase in the size of the organization and in the number of its activities can be derived from the unit as it existed in 1935. At that time there were nine divisions as follows:

1. Administration.
2. Public relations (editorial work and exhibits).
3. Biological investigations, including bird migration and waterfowl distribution; habits of big game; breeding and management of reindeer, caribou, and musk ox in Alaska; and the relations of wildlife to forestry.
4. Food-habits research (stomach analyses, evaluation of refuge food resources, and development of controls for harmful plants).
5. Fur resources (nutrition, embryology, and genetics of fur-farm animals).
6. Game management (predator control, management of refuges, and law enforcement).
7. Land acquisition (selection of areas for refuges and arrangements for getting them).
8. Migratory waterfowl (formulation of the national waterfowl program).
9. Disease investigations.

Up to the end of 1941 a total of 17,643,915 acres of refuges in the United States and Alaska were under the control of the U.S. Fish and Wildlife Service. The efforts of that service along with those of the Canadian government have in 10 years brought the waterfowl population from a dangerously low figure in 1934–1935 to a satisfactorily high figure again. This is only one phase of the work which has led the public to view the U.S. Fish and Wildlife Service as the guardian of the wildlife resources of the nation.

The U.S. Bureau of Fisheries developed as a result of the efforts of the American Fish Cultural Society in 1871. A fish commission was established

which was made up of Federal governmental employees who served without additional pay. The assignment of the commission was to determine the amount of diminution in the food fishes of coastal waters and of the lakes, what caused it, and what should be done about it. The collection of fishery statistics from the Great Lakes and seacoast was begun in 1880. The commission was abolished and the U.S. Bureau of Fisheries was created under the Department of Commerce in 1903. Investigations on salmon had been carried on since 1889, and control of the salmon fisheries was given to the bureau as soon as it was created. Control of the fur-seal herd in Alaska was given to the bureau in 1908, and 2 years later sealing operations were turned over to it also.

At present the greatest emphasis is placed on fishery statistics from coastal waters and the Great Lakes, the seal herd, advice to other governmental landholding agencies such as the U.S. Forest Service on how to manage their fish resources, and the propagation of fish for restocking. The bureau is now a part of the U.S. Fish and Wildlife Service within the Department of the Interior.

The U.S. Forest Service, originally established as the Bureau of Forestry in 1876 and at present controlling 228,632,667 acres of land in 42 states and territories, has found itself with a sizable wildlife problem (24). The fish and game within National Forests are ordinarily under the jurisdiction of state game laws. However, the U.S. Forest Service has a real responsibility in building up the populations of fish and game to provide sport and food for the millions of fishermen and hunters who use the National Forests each year. This responsibility is great enough to warrant increasing manyfold the efforts now being made to correlate timber and wildlife management.

The National Park Service, dating back to 1916, provides enjoyment for the people who use the National Parks. The native flora and fauna are kept as natural as possible, and the killing of mammals or birds is prohibited, except when too great numbers of a species become a menace to other wildlife forms. Jurisdiction over wildlife in the National Parks is usually in the hands of the National Park Service.

The Bureau of Indian affairs has charge of the Indian lands, but the states usually control the take of fish and game by the white man. The Indians can hunt or fish on the reservations regardless of state game laws.

The U.S. Bureau of Reclamation, which is concerned with the construction and operation of irrigation projects in the West, cooperates with other federal and state agencies in caring for wildlife on reclamation lands.

The newest federal agency to work widely with wildlife is the U.S. Soil Conservation Service. Organized in 1933, its work is to cooperate with landowners in using both mechanical and vegetational means of correcting and preventing soil erosion and improving the soil. It has regional biolo-

gists engaged in directing the production of wildlife along with the soil-improvement practices. Emphasis in erosion control has been placed on the use of plants providing food and cover for game.

Other Federal departments connected with wildlife on the national level are the State Department, which makes treaties and carries on correspondence with foreign nations concerning wildlife; the Treasury Department, which regulates customs and supervises any importations; and the Department of Justice, which handles the prosecutions of Federal game-law violations in the Federal courts.

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CHAPTER XXXI

WILDLIFE MANAGEMENT TRAINING

Wildlife management in the United States is a young profession. This is evidenced by the fact that the first American textbook in the field, Leopold's "Game Management," did not appear until 1933. Some of the first men to become interested in wildlife management did so because game animals were part of the resources under their care in organizations like the U.S. Forest Service. Others began wildlife management through the zoological approach, studying the animals as such. These two general approaches have merged themselves into modern wildlife management, in which the student is trained in environmental analysis and control, in the characteristics and needs of individual animals, and in the management techniques that have been developed.

Starting with a few individuals about 1875, the number of men professionally engaged in wildlife management totaled at least 400 at the start of the Second World War. Within this group the Wildlife Society was organized in 1936. It now publishes its own technical periodical, *The Journal of Wildlife Management.*

The wildlife management field as it has now developed is based on *the concept of multiple land use.* Much of the game now harvested in the United States must be produced as a secondary product of the land along with other products such as timber or agricultural crops. Consequently, it is necessary to know the details of producing these crops in order practically to correlate game production with them. Also, it is necessary to know how the growing and harvesting of the crops can affect game and conversely how different densities of game populations can affect the crops.

To be successful, the prospective game manager must be more than a mere farmer, however. He should have, above all else, a love for outdoor work, a keen ability to observe, and a real interest in animals. He must be willing to work under field conditions, doing hard, physical work, sometimes under unfavorable working and living conditions. He must even enjoy the work sufficiently to derive a large measure of his pay from this enjoyment. Then, of course, he must have the aptitude to acquire the necessary technical training needed as a background for his professional work.

Ideally, if a student knew under what conditions he would be working in the future, he could shape his training program accordingly. Actually,

however, most undergraduates do not know whether they will be engaged in wildlife research, management, or administration.

There have been attempts to train men in short courses for work in estate management, game breeding, and law enforcement. These graduates, however, are in the position of having to compete with the practically trained men in the lower paid jobs and with those who have 4 years or more of technical training in the better ones. This places them in a very difficult competitive position.

For those who go into management work such as that carried on by state or federal agencies, a good training at least through the master's degree is needed. For research work the extra training of the doctorate is very desirable. Game management, composed as it is of the major fields of the animal and plant sciences, requires a broad background, and this requirement takes time to acquire.

In this country the development of wildlife management training as such has taken two decades. Although an occasional nature-study course was given previously, the oldest undergraduate course covering the applied phase of game management was not offered until 1924. Two additional courses were established 5 years later. The highest rate of course establishment was reached in 1935 and 1936. During each of these years courses were started in six additional institutions. At the beginning of the Second World War, one or more game management courses were taught at 23 colleges, and in at least two of these parallel curricula were taught in two separate departments.

The number of wildlife management courses taught in the different colleges and universities in the United States varies from a minimum of one course in five colleges to a maximum of seven courses at one institution.

Wildlife work is given in various departments at the different institutions. At 14 of the 23 colleges it is given in the forestry department. The departments of zoology or biology offer the work at five colleges, the departments of agriculture at three, and a combination of agriculture and forestry at one institution.

Graduate work in wildlife management is offered at 19 colleges and universities.

The field of wildlife management training is so broad that the setting up of any one detailed curriculum is as impossible as it is undesirable. However, some courses are especially valuable, and these should form the main superstructure imposed upon the usual basic courses in the sciences and humanities, including general botany and zoology, geology, economics, etc. The ability to write and speak well is a necessity. A well-rounded training program can be thought of as an equilateral triangle with the sides representing the environments, animal biology, and land use (3). King makes the point that it is not important which of the three serves as

the base but rather that each is given its proper emphasis. Some of the fundamental courses in training for the wildlife profession are as follows:

- Environments:
  - Botany:
    - Taxonomy
    - Ecology
  - Limnology
  - Forestry:
    - Silvics
    - Dendrology
    - Timber estimating and mapping
  - Meteorology and climatology
- Animal Biology:
  - Zoology:
    - Taxonomy
    - Physiology
    - Mammalogy
    - Ornithology
    - Entomology
    - Pathology
- Land use:
  - Forestry:
    - Silviculture
    - Forest and range management
  - Agriculture:
    - Soils
    - Agronomy
- Wildlife management
  - Ecology of wild animals
  - Game management materials and technics
  - Principles of game management

Graduate work should be aimed at filling the gaps in the general background and getting special courses such as statistics, genetics, and advanced work in special fields. The thesis work should be so organized that the student gets a good understanding of research techniques in his field and practice in writing a finished report. Usually the thesis problem can be selected from a field in which the student is most interested. The Cooperative Wildlife Research Units sponsored by the U.S. Fish and Wildlife Service, land grant colleges, and the Fish and Game Departments of the states involved offer a very attractive opportunity for graduate training in connection with practical wildlife research.

Wildlife management training is now thought of as a separate field

with its own subject material, educational departments, and a sizable body of alumni. The Wildlife Society has established itself as the group representing the profession and has made a very healthy growth as well as a very valuable contribution to science through its journal.

A student entering this profession can be sure, if he is successful, that he will be able to earn a good living, but there are few chances to become rich. The U.S. Fish and Wildlife Service estimates that following the war, there will be a total of 26 million sportsmen in the United States, giving rise to the prospect of greatly increased demands for wildlife management in the near future.

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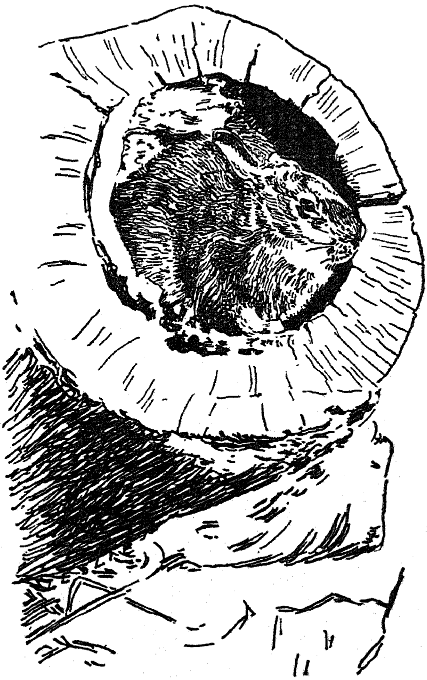

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